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A LOW CRIB DAM ACROSS ROCK RIVER.*

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THE dam which is herein described constitutes one of the structures of the Illinois and Mississippi Canal, better known as the Hennepin Canal, and was built for the purpose of furnishing slack water navigation in Rock River, above the lower rapids, which are located at Milan, Ill.

The location selected requires a dam across the south channel of Rock River, at the head of Carr's Island, 764·2 ft. in length, and another dam across the north channel, 598·3 ft. in length, about 800 ft. below the head of the island, giving a combined length of 1,362·5 ft. of crest. Connecting the two dams is a levee about 1,000 ft. long to protect the island from overflow at high water.

DESIGN.

The general design of the dam, which was prepared by Major W. L. Marshall, Corps of Engineers, U. S. A., called for a rock foundation to withstand a maximum head of 4½ ft., and may be described as a rock filled crib, the woodwork consisting principally of 6 in. by 8 in. pine timbers laid flatwise. The main part of the dam is 13½ ft. in width and the apron 6½ ft., making the total width of the base 20 ft. Immediately adjoining the cribwork above is a filling of clay and quarry refuse of about the same width as the cribwork, and rising in height to the top of the sheet piling.

The main dam and the apron are both covered with 4 in. oak plank, and the upstream face of the dam with two rows of 2 in. pine sheet piling. The oak planks on the main dam are closely fitted together, making it practically watertight, so that the vertical water pressure of the water above the coping is added to the weight of the material in the dam in giving increasing stability to the structure.

The coping of the main part of the dam is built on a slope, rising 2 ft. from the sheet piling to the crest, with a view of preventing projecting limbs and other irregular objects from getting caught on the upstream face and pounding more or less upon the coping, as is usually the case where the slope is in the opposite direction.

From the crest of the dam to the apron is a fall of 3 ft. The top of the apron is about 6 in. above extreme low water, but at the stage at which the ice usually goes out, it is covered with water, more or less, forming a cushion which prevents the ice from cutting the apron as it otherwise would. In the spring of 1895 the ice went out at an unusually low stage, with a thickness of 6 to 12 in., but did no damage. The 6 in. by 8 in. transverse pine timbers, projecting 2 in. above the level of the apron, were cut down to the level of the oak plank to some extent, but this was anticipated and was not considered important.

ROCK RIVER DAM—MAKING THE FINAL CLOSURE OF THE COFFERDAM.

NORTH COFFERDAM.

The construction of the dams was in charge of Mr. L. L. Wheeler, M. Am. Soc. C.E., as resident engineer, with the writer as principal assistant, and Mr. George T. McGee as instrument man. The best form of cofferdam to use in shutting off the river was a matter of considerable investigation, and the contingencies and probable cost were estimated for several different styles. Inasmuch as Rock River is usually at a low stage during the summer, and as the spring of 1894 had been unusually dry, it was decided to build a simple earth embankment across each channel with riprapping on the upstream side to protect them from wave wash.

An area below the north abutment of this dam was stripped in April to furnish a site for a quarry, and early in June the construction of the cofferdam was commenced. The stripping from the quarry, together with the quarry refuse, formed the body of the cofferdam, while a ridge of riprap was kept in advance on the lower side to prevent the current from washing away the loose earth. While the embankment was being started from the north shore of the river, five cribs, 16 ft. square, were settled in line adjacent to Carr's Island. The cribs were built in the shallow water near the shore, by simply boring a hole in each end of each timber and dropping them over the long bolts which held the timbers together at each corner of the crib. The cribs were placed 14 ft. apart, the top covered with 4 in. oak plank, and weighted down with rock and bags of sand. Six by 8 in. timbers, the ends of which were supported by the cribs, were then shoved down into the water, furnishing a length of about 130 ft., to sustain the riprap from being carried away by the current. The riprap and earth cofferdam was then extended to the island, above this protection, and the flow completely shut off. The weight was then taken off the cribs and the lumber used in the construction of the permanent dam. Subsequently the riprap was removed and used for filling in the permanent structure—this recovery of the riprap being the principal argument in favor of placing the stone on the downstream side of this cofferdam.

The end of the cofferdam was kept about 2 ft. above the surface of the water, the wagons being dumped while they stood on the steep slope at the end. A small amount of riprap was placed on the upstream side, above the water line, to protect the embankment from wave wash. The teams returned to the shore by driving through the water on the upper side of the cofferdam. On account of the south channel remaining entirely open, the construction of this cofferdam only raised the water surface about 4 in. The foot of the island was far enough down stream to keep the back water from coming up and interfering with the work. Low secondary cofferdams, a few inches in height, were then built below the main cofferdam, to exclude the seepage that came from the latter. The areas inclosed were from 50 to 200 ft. in length, according to the irregularity of the bottom, and were kept dry by means of hand pumps. The entire amount of material in this cofferdam, including what was in the secondary

ROCK RIVER DAM—CONSTRUCTION OF THE CRIBWORK.

* Published in the Journal of the Association of Engineering Societies, to whose courtesy we are indebted for the illustrations.

dams, was about 300 cubic yards of riprap and 800 cubic yards of quarry stripping.

FOUNDATION.

All sand and gravel, together with as much of the bed rock as could be readily raised with a pick, were then cleared away and the construction of the cribwork commenced. Where the rock was comparatively smooth and solid, iron anchor bolts were set in cement, in holes drilled for the purpose, to which the foundation timbers were bolted so as to insure a greater factor of safety against sliding. The bolts were usually one and one-eighth inches in diameter and twenty-four inches long, but where the bottom was less firm longer bolts were used. Two bolts were generally placed in each panel, the spacing depending on whether the first course consisted of longitudinal or transverse timbers.

CRIBWORK.

All the timbers in the dam were six by eight inches, except the top timber on the upstream face and the top timber under the crest, which were eight inches by eight inches, and eight inches by ten inches, respectively. All of the longitudinal timbers were sixteen feet in length and were arranged so as to break joint regularly and to bring the joints within two feet of the middle of the panels. The bottom course consisted of six rows of timbers, so as to furnish more area for the support of the rock filling, and each of the succeeding courses only five, up to the level of the apron.

In laying the bottom timbers readings were taken on them at frequent intervals with a wye level so as to insure their being started at the proper grade. Where the bottom was comparatively regular the carpenters extended the work several panels at a time with common spirit levels. Throughout the work the bottom timbers were adzed to fit the irregularities in the rock so as to insure greater safety against sliding.

The transverse timbers are all spaced eight feet apart except that in the course above the bottom longitudinals an extra timber fourteen feet long is placed in the middle of each eight foot panel, so as to assist in receiving the weight of the rock filling. On the downstream face of the dam, under the apron as well as under the coping, a two foot block is placed under each joint, to which the longitudinals are thoroughly bolted. The intention was to increase the tensile strength on that side, so that in case any part of the dam should ever be called upon to act as a beam, it would have proportionately greater transverse strength.

DRIFT BOLTS AND SPIKES.

The size of all the drift bolts was three-quarters inch by sixteen inch except that ten inch bolts were used at the bottom wherever the first course happened to consist of longitudinals, and eighteen inch in putting on the eight by eight inch and eight by ten inch longitudinals. One bolt was driven at each intersection, the bolt being always started through a cross timber. Holes were bored to the full depth of the bolts one-sixteenth inch smaller in diameter.

The four-inch oak planking on the coping and apron was fastened down with two seven-sixteenths inch by eight inch boat spikes at each purlin, for which seven-sixteenths inch holes were bored. The first row of two inch sheet piling was held temporarily with 20d. wire nails until the second row was put on, both rows being carried along together, after which they were fastened permanently with four three-eighths inch by seven inch boat spikes per running foot, driven without boring.

ROCK FILLING.

The filling of the dam was carried on simultaneously with the cribwork, and the stone packed in between the timbers so as to obtain as much weight as possible. The filling immediately adjoining the cribwork on the upstream side was carried along in a narrow embankment as fast as the sheet piling was put on. This permitted the rock teams to be driven up close to the sheet piling, and made it possible to throw the stone directly into the cribwork from the wagons. When the dam was nearly in the condition in which it was to be left during the construction of the South Dam, this embankment was widened by casting over material from the cofferdam, until the latter was finally allowed to break through.

TEMPORARY SLUICEWAY.

The temporary sluiceway in the North Dam, previously referred to, kept the water above the dams about two feet lower than if the dam had all been completed at one time—and allowed the South Cofferdam to be made lower by the same amount.

A temporary bracket consisting of a vertical post and two braces was set up at each panel point. On the upstream side of the posts, near the top, was supported a line of four inch by twelve inch pine wales. This brought the wales on line with the permanent sheet piling, which formed the bottom of the sluiceway. In shutting off the sluiceway subsequently, in order to complete this portion of the dam, it was necessary simply to shove the sheet piling down in front of the wale, and allow them to catch on the top of the permanent sheet piling. The vertical posts and the long braces were used in the completion of that half of the dam, and the balance of the lumber on other parts of the canal, so that there was no waste of lumber. During the construction of the South Dam this sluiceway carried the whole discharge of the river, amounting to about 2,500 cubic feet a second.

SOUTH DAM.

The construction of the South Cofferdam was commenced on July 24, and completed on August 4. In this case the ridge of riprap was extended ahead of the earthen portion on the upstream side, so as to permit the teams to return to the shore on the lower side, as the increased depth caused by shutting off the water completely would not permit the same plan to be used as at the North Dam. On account of the greater amount of water with which it was necessary to contend in making the final closure, ten cribs were erected adjacent to the island instead of five. These were settled on the upstream edge of the cofferdam. When the end of the cofferdam had been extended so as to come under the protection of the first crib, wales were placed across the spaces between the cribs and driving sheet piling was commenced from both ends of this three hundred foot space covered by the cribs. Under this protection work on the rock and earth cofferdam was also carried on from both ends. As the ends of the cofferdam were extended part of the sheet piling was taken up and used a second time, and only in making the final closure for the last hundred feet was it necessary to double the piling. The method of dumping the wagons and the final closing behind the cribs are shown in the accompanying illustration.

When the comparatively tight embankment had been completed, the weight was taken off the cribs and the lumber used in the permanent structure. Most of the clay and riprap for this cofferdam were taken from a waste pile of material that had been excavated from the lock pit at the south end of the dam.

As indicated by the borings, it was found that the foundation of this dam was not as good as the other, inasmuch as a stretch of hard clay was encountered 50 feet in length, and a bed of compact sand and gravel 120 feet in length. This was excavated to a depth of about three feet below the bed of the river, and the material used as filling above the dam. As the cribwork progressed, the V-shaped trench that remained below the apron was filled with heavy stone, as shown in the details.

The rock filling for this dam was obtained considerably cheaper than for the other from the fact that on this side about 75 per cent. of the rock was readily quarried from the bed of the river without explosives.

FORCE EMPLOYED.

During the construction of the South Cofferdam the force consisted of about fourteen teams and fifty laborers. For a few days while the preparation of the foundation was being rushed the number of laborers was increased to 130.

During the erection of the cribwork the force consisted of sixteen carpenters and about fifty laborers, about one-third of the latter assisting the carpenters in carrying timbers, boring and driving bolts and spikes. The number of teams remained the same throughout the work.

COMPLETING NORTH DAM.

After the completion of the South Dam the temporary sluiceway in the North Dam was closed as previously described, and the upper part of the dam completed readily under the protection of the sheet piling. As soon as the sheet piling was in place the lower braces were knocked out, so that there was nothing to interfere with putting on the purlins. As the coping was gradually extended from the abutment, braces were put in from the waling piece back to the top of the oak plank. This permitted the post and the remaining brace to be knocked out, as the spikes in the sheet piling were sufficient to support the weight of the waling piece. The stone filling was thrown into the crib from a barge which was towed alongside the sheet piling. The completion of this part of the dam occupied four and a half days, including the erection and removal of the sheet piling.

FISHWAYS.

At the time the dams were built a fishway was constructed at the south end of each dam. It was found, however, that they were unsatisfactory, for several reasons, and during the following summer they were modified according to the plan shown in the details. By increasing the number of wings from five to nine the velocity of the water was checked so that fish can readily ascend from step to step. The upper end is arranged so that the fish go out into comparatively quiet water, instead of having to jump over the crest, while at the same time the amount of water entering the fishway can be regulated to suit the stage of the river. They also comply with the theory that a fishway, in order to be found readily by the fish, should not extend down stream any farther than the apron of the dam. The cribs above the fishways, together with their protected position adjacent to the south abutments, are designed to protect them from ice. When the fish are running up stream the larger ones can frequently be seen entering and leaving the fishways. By shutting off the water at the upper end, as many as sixty fish of various species have been found in it at one time, some of which have been from two to three feet in length.

The total amount of lumber in both dams is 330,190 ft. b. m. The cost of the labor expended in putting this in the dams amounted to $1,914, or $5.80 per M.

The total amount of rock filling in the North Dam is 1,240 cubic yards and in the South Dam 2,350 cubic yards, making the total for both dams 3,590 cubic yards. The total cost of the labor on both dams was about $10,000.

TOTAL COST OF THE TWO DAMS.

The total cost of the two dams, including labor and material, is as follows:

Rent of land	$217 40
Labor	9,994 80
Oak lumber	2,919 00
Pine lumber	3,086 60
Explosives	151 19
Drift bolts, spikes, etc.	804 98
Total	$17,173 97

The total length of the two dams being 1,362½ ft., makes the cost per lineal foot $12.60.

THE REPRODUCTION OF DIFFRACTION GRATINGS.*

I HAVE first to apologize for the very informal character of the communication which I am about to make to the club; I have not been able to put anything down upon paper, but I thought it might be interesting to some to hear an account of experiments that have now been carried on at intervals for a considerable series of years in the reproduction—mainly the photographic reproduction—of diffraction gratings. Probably most of you know that these consist of straight lines ruled very closely, very accurately, and parallel to one another, upon a piece of glass or speculum metal. Usually they are ruled with a diamond by the aid of a dividing machine; and in late years, particularly in the hands of Rutherfurd and Rowland, an extraordinary degree of perfection has been attained. It was many years ago—nearly twenty-five, I am afraid—that I first began experiments upon the photographic reproduction of these divided gratings, each in itself the work of great time and trouble, and costing a good deal of money. At that time the only gratings available were made by Nobert, in Germany, of which I had two, each containing about a square inch of ruled surface, one of about 3,000 lines to the inch and the other of about 6,000. It happened, accidentally, that the grating with 3,000 lines was the better of the two, in that it was more accurately ruled and gave much finer definition upon the solar spectrum; the 6,000 line grating was brighter, but its definition was decidedly inferior; so that both had certain advantages, according to the particular object in view.

If it comes to the question of how to make a grating by photography, probably the first idea to occur to one would be that it might be a comparatively simple matter to make a grating upon a large scale and then reduce it by photography; but if one goes into the figures, the project is not found so promising. Take, for instance, a grating with 10,000 lines to the inch; if you magnified that, say 100 times, your lines would then be 100 to the inch; if you magnified it 1,000 times, they would still be 10 to the inch, and that would be a convenient size, so far as interval between the lines was concerned, but think what would be the area required to hold a grating magnified to that extent. By the time you have magnified the inch by 100 or 1,000, you would want a wall of a house or of a cathedral to hold the grating. If the problem were proposed of ruling a grating with 6,000 lines to the inch, with a high degree of accuracy, it would be easier to do it on a microscopic scale than upon a large scale, leaving out of consideration the difficulty of reproducing it. And those difficulties would be insuperable, because, although with a good microscopic object glass it would be easy to photograph lines which would be much closer together than 3,000 or 6,000 to the inch, yet that could only be achieved over a very small area of surface—nothing like a square inch; and if it were required to cover a square inch with lines 6,000 to the inch, it would be beyond the power, not only, I believe, of any microscope, but of any lens that was ever made. So that that line of investigation does not fulfill the promise which at first it might appear to give; and, in fact, there is nothing simpler or better than to copy the original ruled by a dividing engine, by the simple process of contact printing.

For this purpose some precautions are required. You must use very flat glass, by preference it should be optically worked, although very good results may be obtained on selected pieces of ordinary plate. Of course no one would think of making such a print by diffused daylight; but the sun itself, or a point of light from any suitable source, according to the nature of the photographic process which is adopted, permits quite well of the reproduction of any grating of a moderate degree of fineness. I have used almost all varieties of photographic processes in my time. In the days when I first worked, the various dry collodion processes were better understood than they are now; the old albumen process was extremely suitable for such work as this, on account of the almost complete absence of structure in the film and the very convenient hardness of the surface, which made the finished result comparatively little liable to injury. I used with success the dry collodion processes, the tannin process among others, and also some of the direct printing methods, such as the collodio-chloride. The latter method, worked upon glass, gave excellent results, particularly if the finished print was treated with mercury in the way commonly used for intensification, except that, in the treatment of a grating with mercury, it is desirable to stop at the mercury and not to go on to the blackening process used in the intensification of negatives. From the visual point of view, the grating, after intensification—if one may use the term—with mercury, looks much less intense than before, but, nevertheless, the spectra seen when a point or slit of light is looked at through the grating become very much more brilliant.

I used another process at that time, more than twenty years ago, which gave excellent results, but had not the degree of certainty that I aimed at; namely, a bichromated gelatine process, similar to carbon printing, except that no pigment was employed. A glass plate was simply coated with bichromated gelatine of a suitable thickness—and a good deal depended upon hitting that off correctly; if the coating was too thin, the grating showed a deficiency of brightness, whereas, if it was too thick, there might be a difficulty in getting it sufficiently uniform and smooth on the surface. However, I obtained excellent gratings by that process, most of them capable of showing the nickel line between the two well-known sodium or D lines in the solar spectrum, when suitably examined. The collodio-chloride process was comparatively slow, and bichromated gelatine required two or three minutes' exposure to sunlight to produce a proper effect; but for the more sensitive developed negative processes a very much less powerful light or a reduced exposure was needed.

The performance of the copies was quite good, and, except where there was some obvious defect, I never could see that they were worse than the originals; in fact, in respect of brightness it not unfrequently happened that the copies were far superior to the originals, so that in many cases they would be more useful. I do not mean by that, however, that I would rather have a copy than an original, if any one wanted to make me a present. There seems to be some falling off in copies, so that they cannot well be copied again, and if you want to work upon spectra of an extremely high order, dispersed to a great extent laterally from the direct line, a copy would not be satisfactory. The reproduction of gratings on bichromated gelatine is easily and quickly accomplished; there is only the coating of the glass overnight, rapid drying to avoid crystallization in the film, exposure, washing, and drying. In order to get the best effect, it is usually desirable to treat the bichromated copies with hot water. It is a little difficult to understand what precisely happens. All photographers know that the action of light upon bichromated gelatine is to produce a comparative insolubility of the gelatine. In the carbon process, and many others in which gelatine is used, the gelatine which remains soluble, not having been sufficiently ex-

* An address delivered by Lord Rayleigh at the eighth annual conference of the Camera Club.—From Nature.

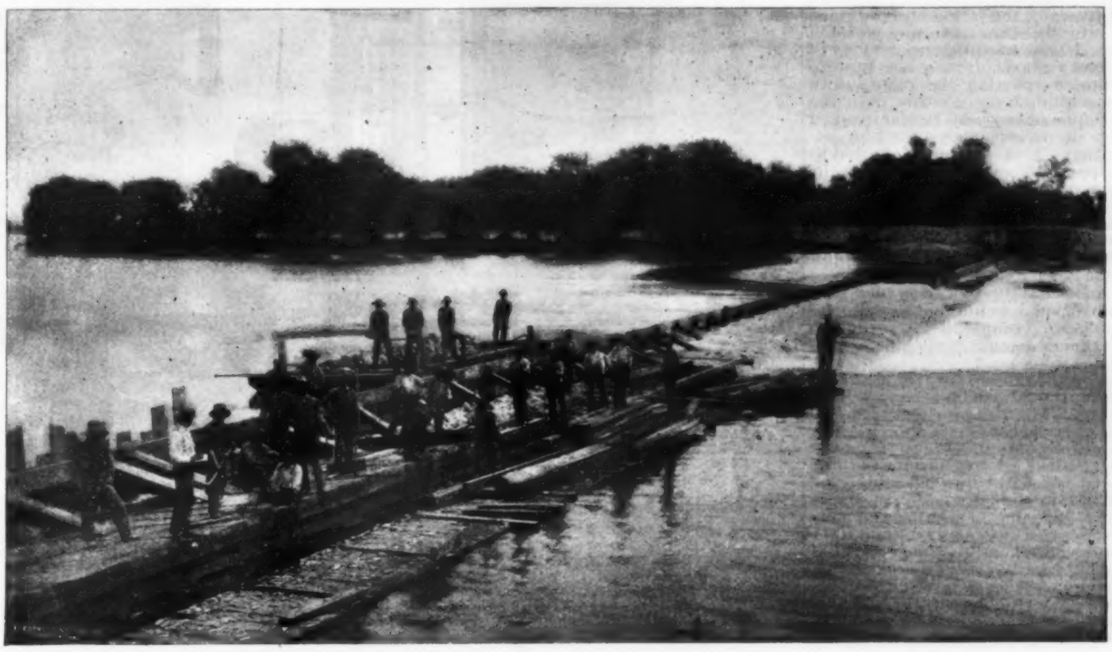
posed to light, is fairly washed away in the subsequent treatment with warm water; but for that effect it is generally necessary to get at the back of the gelatine film, because on its face there is usually a layer which is so insoluble as not to allow of the washing away of any of the gelatine to be found behind. But in the present case there is no question of transferring the film, which remains fixed to the glass, and therefore it is difficult to see how any gelatine could be dissolved out. However, under the action of water, the less exposed gelatine no doubt swells more than that which has received more exposure and has thus lost its affinity for water; and while the gelatine is wet it is reasonable that a riblike structure should ensue, which is what would be required in order to make a grating, but when the gelatine dries, one would suppose that all would again become flat, and indeed that happens to a certain extent. The gratings lose a great deal of intensity in drying but, if properly treated with warm water, the reduction does not go too far, and a considerable degree of intensity is left when the photograph is dry.

Although it belongs to another branch of the subject, a word may not be out of place as to the accuracy with which the gratings must be made. It seems a wonderful thing, at first sight, to rule 6,000 lines to an inch at all, if you think of the smallest interval that you can readily see with the eye, perhaps one-hundredth of an inch, and remember that in these gratings there are sixty lines in a space of one-hundredth of an inch, and all disposed at rigorously equal intervals. Those familiar with optics will understand the importance of extreme accuracy if I give an illustration. Take the case of the two sodium lines in the spectrum, the D lines; they differ in wave length by about a thousandth part; the dispersion—the extent to which the light is separated from the direct line—is in proportion to the wave length of the light, and inversely as the interval between the consecutive lines on the grating; so that, if we had a grating in which the first half was ruled at the rate of 1,000 to the inch and the second half at the rate of 1,001 to the inch, the one half would evidently do the same thing for one soda line as the other half of the grating was doing for the other soda line, and the two lines would be mixed together and confused. In order, therefore, to do anything like good work, it is necessary, not only to have a very great number of lines, but to have them spaced with most extraordinary precision; and it is wonderful what success has been reached by the beautiful dividing machines of Rutherfurd and Rowland. I have seen Rowland's machine at Baltimore, and have heard him speak of the great precautions required to get good results. The whole operation of the machine is automatic; the ruling goes on continuously day and night, and it is necessary to pay the most careful regard to uniformity of temperature, for the slightest expansion or contraction due to change of temperature of the different parts of the machine would bring utter confusion into the grating and its resulting spectrum.

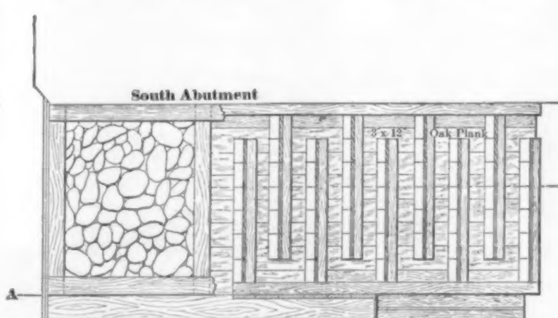
In printing, the contact has to be pretty close, and the finer the grating, the closer must the contact be. I experimented upon that point by preparing a photographic film upon a slightly convex surface, and using that for the print; then, where the contact was closest, the original of course was very well impressed, and round that one got different degrees of increasingly imperfect contact, and one could trace in the result what the effect of imperfect contact is. I found that, both with gratings of 3,000 and 6,000 lines to the inch, good enough contact was obtained with ordinary flat glass; but when you come to gratings of 17,000 or 20,000 lines to the inch the contact requires to be extremely close, and in order to get a good copy of a grating with 20,000 lines per inch it is necessary that there should nowhere be one ten-thousandth of an inch between the original and the printing surface—a degree of closeness not easily secured over the entire area. It is rather singular that, though I published full accounts of this work a long time ago, and distributed a large number of copies, the process of reproducing gratings by photography did not become universally known, and was rediscovered in France, by Isarn, only two or three years since.

One reason why photographic reproduction is not practiced to a very great extent is, that the modern gratings—such as Rowland's—are ruled almost universally upon speculum metal. A grating upon speculum metal is very excellent for use, but does not well lend itself to the process of photographic copying, although I have succeeded to a certain extent in copying a grating ruled upon speculum metal. For this purpose the light had to pass first through the photographic film, then be reflected from the speculum metal, and so pass back again through the film. Gratings such as could easily be made by copying from a glass original are not readily produced from one on speculum metal, and I think that is the reason why the process has not come into more regular use. Glass is much more trying than speculum metal to the diamond, and that accounts for the latter being generally preferred for gratings; indeed, the principal difficulty consists in getting a good diamond point, and maintaining it in a shape suitable for making the very fine cut which is required.

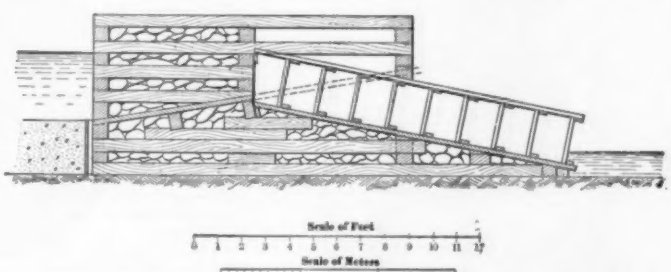
I may now allude to another method of photographic reproduction which I tried only last summer. It happened that I then went with Prof. Meldola over Waterlow's large photo-mechanical printing establishment, and I was very much interested, among many other very interesting things, in the use of the old bitumen process—the first photographic process known. It is used for the reproduction of cuts in black and white. A carefully cleansed zinc plate is coated with varnish of bitumen dissolved in benzole, and exposed to sunlight for about two hours under a negative, giving great contrast. Where the light penetrates the negative the bitumen becomes comparatively insoluble, and where it has been protected from the action of light it retains its original degree of solubility. When the exposed plate is treated with a solvent, turpentine or some solvent milder than benzole, the protected parts are dissolved away, leaving the bare metal; whereas the



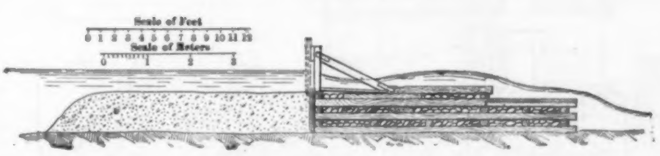
ROCK RIVER DAM—TEMPORARY SLUICEWAY.



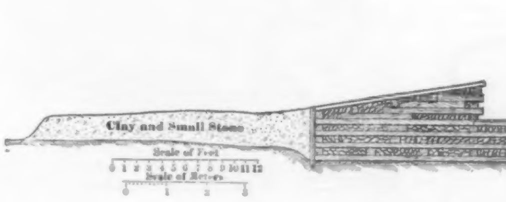
Plan of Fishway.



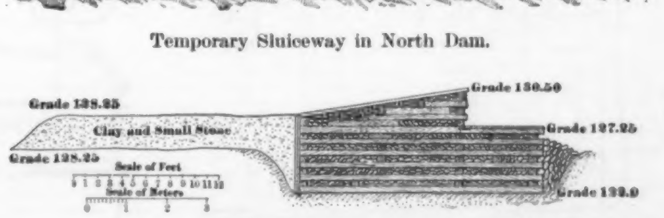
Section A-B of Fishway.



Temporary Sluiceway in North Dam.



Typical Section on Rock Foundation.



Typical Section on Gravel Foundation.

ROCK RIVER DAM—DETAILS OF CRIBWORK AND FISHWAY.

parts that have received the sunlight, being rendered insoluble, remain upon the metal and protect it in the subsequent etching process. I did not propose to etch metal, and, therefore, I simply used the bitumen varnish spread upon glass plates, and exposed the plates so prepared to sunshine for about two hours in contact with the grating. They are then developed, if one may use the phrase, with turpentine; and this is the part of the process which is the most difficult to manage. If you stop development early, you get a grating which gives fair spectra, but it may be deficient in intensity and brightness; if you push development, the brightness increases up to a point at which the film disintegrates altogether. In this way one is tempted to pursue the process to the very last point, and, although one may succeed so far as to have a film which is quite intact so long as the turpentine is upon it, I have not succeeded in finding any method of getting rid of the turpentine without leading to the disintegration of the film. In the commercial application of the process the bitumen is treated somewhat brutally—the turpentine is rinsed off with a jet of water; I have tried that, and many of my results have been very good. I have also tried to sling off the turpentine by putting the plate into a kind of centrifugal machine; but by either plan the film in which the development has been too far pushed is liable not to survive the treatment required for getting rid of the turpentine. If the solvent is allowed to remain, we are in another difficulty, because then the developing action is continued and the result is lost. But if the process is properly managed, and development stopped at the right point, and if the film be of the right degree of thickness, you get an excellent copy. I have one here, 6,000 lines to the inch, which I think is about the very best copy I have ever made. The method gives results somewhat superior to the best that can be got with gelatine; but I would not recommend it in preference to the latter, because it is very much more difficult to work, unless some one can hit upon an improved manipulation.

I will not enlarge upon the importance of gratings; those acquainted with optics know how very important is the part played by diffraction gratings in optical research, and how the most delicate work upon spectra, requiring the highest degree of optical power, is made by means of gratings, ruled on speculum metal by Rowland. I suppose the reason why no professional photographer has taken up the production of photographic gratings is the difficulty of getting the glass originals. They are very expensive, and I do not know where they are now to be obtained. It seems a pity that photographic copies should not be more generally available. I have given a great many away myself; but e lucational establishments are increasing all over the country, and for the purpose of instructing students it is desirable that reasonably good gratings should be placed in their hands, to make them familiar with the measurements by which the wave length of light is determined.

THE CHEVALET HEATER-DETARTARIZER.

THE accompanying engravings, Figs. 1, 2, and 3, represent general and sectional views of a feed water heather and softener which we have had an opportunity of inspecting at work at the central station of the House to House Electric Light Company, West Brompton, where it is treating and supplying nearly 3,000 gallons of feed water per hour for a battery of Babcock and Wilcox boilers, with very satisfactory results, using only exhaust steam. The purification of the feed water is brought about by boiling the water by the heat obtained from exhaust steam, thereby depositing the lime in the form of compact mud, or soft scale, in the apparatus itself, whence it is periodically removed, no attempt being made to collect and blow it out in a more or less fluid condition.

Referring to the sectional views, Figs. 1 and 2, the cold water enters by the funnel, A, at the top of the machine, and flows downward through the various trays or sections to the tank forming the base of the apparatus, from which it flows at boiling heat to the feed pumps. The cast iron trays or sections of the machine are all similar, and in working remain about half full of water, which flows downward from one section to another through the tapered overflow tubes, C, till it finally reaches the bottom tank above mentioned, through the parallel overflow pipe, D. The exhaust steam enters at B, and passes upward as indicated by the arrows, through a number of tubular openings in the bottom of each section, each opening being surmounted by an inverted cap. The steam reaches the interior of these caps and cannot escape except by blowing its way through the water into which the caps dip.

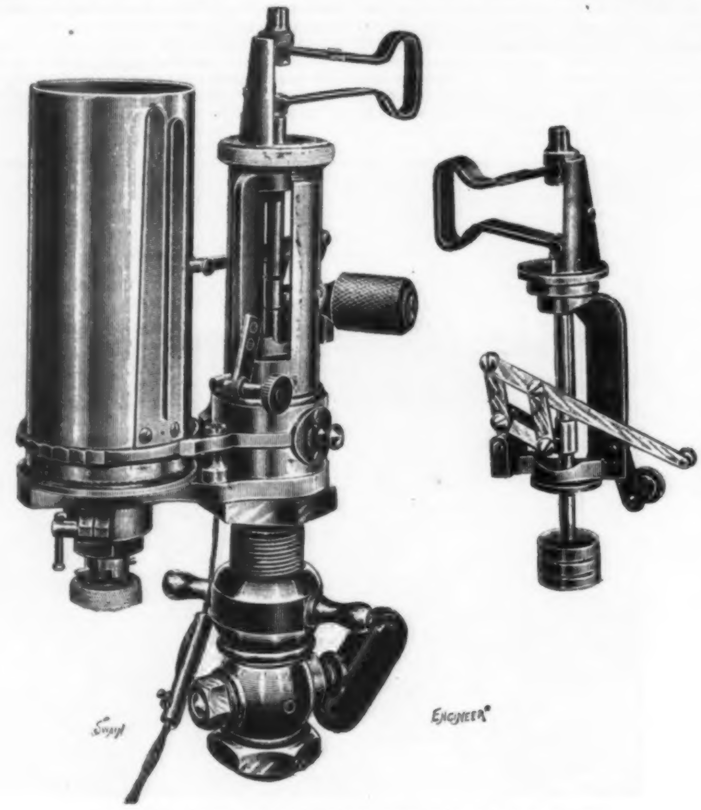
The boiling action goes on in all the sections, with the effect of liberating the carbonic acid gas dissolved in the crude cold water, and the carbonate of lime becoming insoluble is precipitated on the surfaces of the sections with which it comes in contact. When cleaning becomes necessary, the sections are lifted down and the soft scale scraped away, an operation occupying from four to five hours in the case of the larger sizes.

For dealing with the sulphate of lime which cannot be precipitated by boiling at 212 deg., a small amount of carbonate of soda is supplied, in the form of solution, to the water as it enters the apparatus. A very small pump is employed for the purpose, arranged to be operated from some moving part on the feed pump, so that a predetermined amount of soda solution is injected at each stroke of the feed pump. The soda by double decomposition changes the sulphate of lime to carbonate of lime, which is then precipitated by the boiling action, and the sulphate of soda remains in the water in the form of a permanently soluble salt. The water as it reaches the feed pump is stated to retain not more than 3 deg. of hardness, the amount of hardness of the crude water having no effect beyond necessitating a rather larger size of apparatus if exceeding about 18 deg. It is claimed that should any grease contained in the exhaust steam evade the baffle-plate placed in the separator, E, it is prevented from entering the boilers by adhering to the lime with which it is precipitated, and an inspection of the scale certainly tends to bear out this theory.

It is claimed for this apparatus, says the Engineer, that the results obtained are regular and trustworthy, that its efficiency does not diminish, and that its heating and purifying powers remain the same up till the moment when the scale commences to impede the flow of water and steam, when the trays should be removed and the scale chipped off. The maker of the apparatus is Mr. William Boby, Union Court, Old Broad Street, London.

A NOVEL INDICATOR.

THE accompanying engraving illustrates a new form of indicator now being introduced by Messrs. Elliott, of St. Martin's Lane. The engraving explains itself so fully that little description is necessary.



ELLIOTT'S NEW OUTSIDE SPRING INDICATOR.

Instead of the ordinary coiled spring a flat "sugar tongs" spring is used. It can be slipped into place in a moment, and we understand that they are far more easily calibrated, and more uniform in range than the ordinary helical spring. Besides, they are not subject to the heat of the steam, and will, indeed, remain cool during long continued use.

All the remaining details are so obvious that no description is needed. From personal experience we can

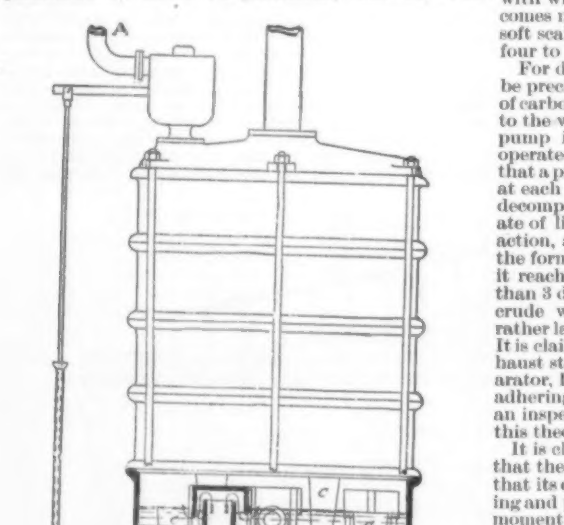


FIG. 1.

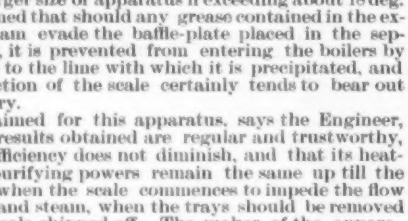


FIG. 2.

FIG. 3.

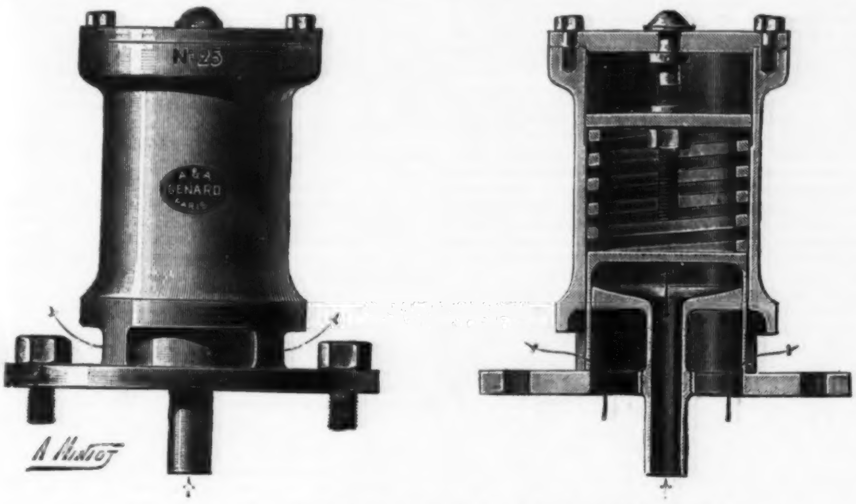
THE CHEVALET HEATER-DETARTARIZER.

testify to the excellence of this indicator, at all events up to about 300 revolutions per minute and 180 lb. pressure.—Engineer.

GENARD'S SAFETY VALVE.

THE fact is generally recognized that the ordinary safety valve plays upon steam boilers merely the part of an alarm. The property of limiting pressure that has been attributed to it has been done so wrongly.

The phenomena that intervene in its operation are so well known that it is useless to revert to them. It will suffice to say that at the slightest rising of the valve, the dynamic action of the steam is substituted for static pressure, and from such substitution there results a notable diminution of the charge necessary for the lifting and gradual ascent of the valve. The latter falls back upon its seat and rises again by a fraction of an inch without being able, by reason of the depression caused by the outflow of steam, to rise sufficiently to re-establish the normal pressure.



FIGS. 1 AND 2.—GENARD'S SAFETY VALVE—SPRING TYPE.

There is thus produced a pounding upon the narrow edges of the valve seat and an intermittent discharge proportional, not to the section of the passage, but to its circumference, and, consequently, manifestly inadequate.

In order to preserve the equilibrium of the forces that act simultaneously upon the valve, manufacturers have naturally been led to introduce into its operation a stress to compensate for the depression caused by the efflux of steam, for the sake of permitting of the wide opening of it for a determinate variation in pressure, and of keeping it raised.

An endeavor has likewise been made, through proper correctives, to render the rising of the valve proportional to the value of the excess of pressure, and to bring about this, as well as the closing, in a progressive manner.

Up to the present the production of such compensating stress has been more particularly required of the live force due to the efflux of the steam. In a new safety valve devised by Mr. A. Genard it is the static pressure of the steam that intervenes in its operation, in the opening as well as in the closing, in such a way as to render both progressive in the opening until the rise necessary for the rapid efflux of the steam is attained, and in the closing until the valve falls back upon its seat without a shock.

Figs. 1 and 2 show the spring type of the Genard valve. This consists of a bronze cylinder fixed upon the boiler through a flange. Upon the periphery of the central orifice of the latter there is arranged a narrow edged conical seat, and above this the cylinder is widened and provided with several apertures that afford wide outlets for the steam.

The valve constitutes a sort of cylindrical receiver that rests through its thin wall upon the conical seat and penetrates the cylinder, wherein a contact is effected through three vertical slides, which, while assuring a perfect guiding, give rise to scarcely any friction.

The aperture of the seat carries a crossbar, into the center of which is screwed the tube of a diaphragm hollowed out in the form of a funnel and accurately adjusted in the interior of the valve, which it penetrates to a certain height. A steel spring inclosed in the upper part of the cylinder exerts the necessary stress upon the valve to balance the normal pressure. The tension of this screw is regulated by raising or lowering its supporting disk by means of the central screw, whose lower extremity limits the upward travel of the valve. The head of this screw, which is situated outside of the cover, can be revolved only by means of a special key. It cannot, therefore, be tampered with by the fireman. As a further measure of safety, it may be sealed with lead.

Finally, under its disk the screw is provided with a nut whose position, determined in advance, limits the descent of the disk, and, consequently, the tension that it is possible to give the screw without having to take the valve apart again.

In service, the steam, which must be expelled at the beginning of a rise, fills the valve beneath the diaphragm, but exerts no effect for the opening of the valve. This role is performed solely by the steam that the tube of the diaphragm takes from the boiler and causes to act upon the bottom of the valve.

When the stress of the spring no longer overcomes the pressure thus exerted, the valve, in rising, permits the steam to escape between its base and its seat, but it continues, none the less, to receive the pressure that prevails in the boiler, since the funnel shaped diaphragm is adjusted with such precision that, without giving rise to any griping, it prevents the steam from escaping through its periphery. Besides, its tube permits the water of condensation to flow freely to the boiler. Under such circumstances the progressive ascent of the valve may, if the excess of pressure admits of it, reach its maximum, equal to a quarter of the diameter of the escapement orifice. In measure as the pressure decreases, the valve descends, and finally closes without a shock and without necessitating a fall of pressure in the generator below that at which it is registered.

The type of valve represented in Fig. 3 differs from the preceding only in the use of a lever with counterpoise. With this arrangement the charge remains nearly invariable during the ascent of the valve, and the latter is capable of reaching its maximum height much more easily than before. This apparatus is as simple as it is strong. The number of parts are reduced to their simplest expression. The friction is slight and the valve has no contact except at its base and the four internal guides.

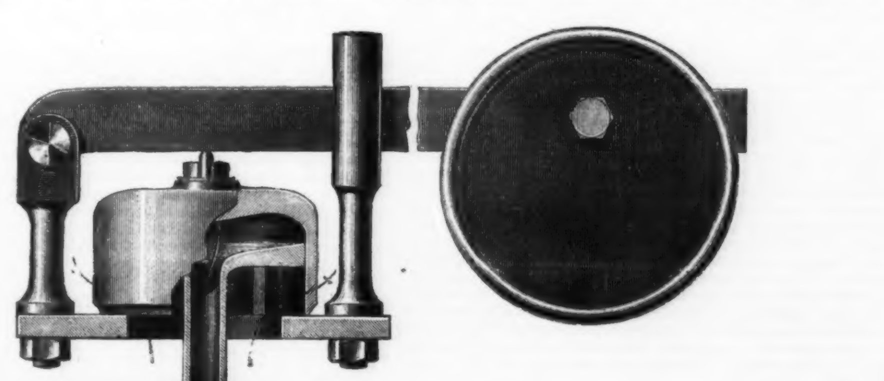


FIG. 3.—LEVER TYPE.

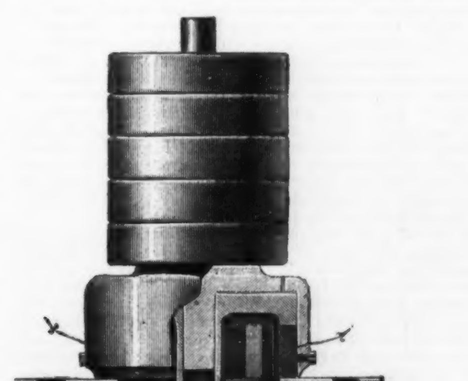


FIG. 4.—DIFFERENTIAL TYPE.

We find the same character of simplicity again in the differential type (Fig. 4), which is so called because the pressure of the steam, instead of acting upon the entire section of the bottom of the valve, is exerted only upon a central rod cast in a piece with the latter and forming a sort of plunger that moves in the tube of the diaphragm. This arrangement permits of reducing the size of the weights that load the valve and of employing cast iron disks simply. Over the lever with counterpoise it presents the same advantage that it has over the spring, that of rendering the load constant at any point of the rising of the valve.—Revue Industrielle.

TRANSFERRING FILMS WHILE WET.

COLLODION.

WE have been asked to publish some remarks on this topic so as to cover wet collodion work, as many cases arise in which it might be useful, which is so true that it will be worth while to refer to some of the more prominent. Though "process" dry plates are now running the old wet collodion very close, it cannot be doubted—and in this the collodion manufacturers would bear out our statement—that there is still a considerable amount of work done in which the silver bath plays its old part.

When special signatures, mottoes, or a descriptive title are required to be added to an existing negative, a transferred collodion film is most useful, owing to the absolute transparency that may be given to the groundwork of the lettering, etc. A small collodion negative made in the camera, with a ripe sample of collodion, requires simply to be floated off its support, transferred to the required place in the negative—gelatine or otherwise—and the whole allowed to dry, for a negative to be produced, on which, when varnished, it would defy the powers of the keenest critic to discover the presence of anything but the letters or design. If the recipient negative be of collodion, it should first be varnished with ordinary varnish, or coated with hard gelatine.

This same method was once vended as a secret process for introducing backgrounds into portrait negatives. To do this, the film containing the subject to be added is treated with iodine and cyanide in the portion where the figure is to occupy, either before or after transferring. In the latter case, the plate to be improved must be varnished to prevent action upon its film. We can assure our readers that the plan is an admirable one for the purpose—with the exercise of a little ingenuity considerable amount of composition can be so introduced. We have seen negatives containing several successive films so attached, each providing its own share to the composition. Of course, the same thing can be done with gelatine films, but they are less amenable to chemical reduction of image; trouble might be apprehended from possible enlargement, and consequent necessary diminution by spirit. Little vignettes at the corners of a portrait or view are easily introduced by these means, and it only needs familiarity with the process to see a hundred different uses in a similar direction to which it may be applied. We have seen it employed very successfully when a negative has been unfortunately produced on a dirty plate, causing silvery fog between film and glass. The danger of this lies in the fragile adhesion that exists in these spots, and, further, in the possibility of the collodion blistering when the varnish is applied to the heated plate. Such films will be quite adherent when applied to a collodionized glass, and the water removed by soaking in methylated spirit before drying the plate.

Finally, when a reversed collodion negative is required, in the absence of a reflecting mirror, for single transfer carbon, or for collotype, or other mechanical work, the power of transferring and reversing the film is most useful. When, for instance, as so often happens in professional work, an old faded collodion or daguerreotype positive is required to be enlarged, nothing can excel the ease and certainty of wet collodion, which readily gives an image developable up to full printing density, and of a quality hitherto difficult to obtain by any dry plate. The great stumbling block to printing it in carbon is that the fact of a negative being non-reversed requires the print, if wished for in carbon, to be done by double transfer; this limits the range of surfaces. A double transfer print on rough Whatman, for instance, is next to impossible.

All that is needed is to transfer the collodion film to another glass, but in a reversed position.

The modus operandi is simple, and very like that with gelatine; but the film being so much more tender renders great care needful. The first stage is the loosening of the film from the glass. This also, like gelatine, is simply done by flooding the plate with, or immersing it in, an acid solution—almost any acid; we prefer citric acid. If a ten per cent. solution be used, the film should be quite loose in about a quarter of an hour or less, the action being plainly visible by the way the liquid seems to roll under the film. The chief difficulty with collodion films lies in their close adherence at the edge of the plate. To avoid the occurrence of this difficulty it is best to remove a narrow margin of film all round the plate; then, when the action of the acid is complete, the film will float off in the dish of water in which it is placed, and with the utmost gentleness of movement, to avoid any creasing or doubling of the film, which is very likely to happen if any violent movement be imparted to the water. It

is easy for the skilled hand to remedy even this mishap; but it is better to avoid it. Collodion films may be transferred to plain glass, but it is better always to use one coated, for example, with collodion washed with water till free from greasiness. The prepared plate is first lowered into the dish of water, and the film-loosened negative then put in; the dish should be double the size of the plate. If a reversed negative is required, the plate whose film has been thus loosened by acid is gently placed, film downward, into the water, and, when the disturbance has ceased, one end of the plate is slightly raised; and the now bare glass gradually withdrawn by a sort of sliding action. If this is done quietly enough, the film will float without a crease. Then the collodionized glass is gently lifted, very slightly on a slant, out of the water, its position being manipulated so as to be exactly under the floating film, and, further, one end of the glass with one side of the film raised above the water. Then the whole must be slowly withdrawn in the same slanting direction.

If it be found that the film is misplaced and a portion hangs over the glass, the process must be gone through again, though it is quite possible with delicate fingering to alter the position of the film on the new support, and without tearing it, so long as there is a pool or layer of water upon it. There is a danger at this stage, if the pool is suddenly drained off, for it to form a sort of pocket in the film, and then to break it open by the weight of the inclosed water. To name this danger is to prevent its happening. The rearing up to dry must not be hurried, or the whole film may slip down in a heap and be spoiled. If there is margin to spare in the transferred film, an excellent plan is to allow a slight portion to overlap the edge of the new glass support, and keep that edge uppermost. Dry plate workers are not so accustomed as old wet plate hands to always leave plenty of margin on their negatives, so as to avoid damage to the slight film from various causes. We have only one other defect in transferring to provide against, we refer to the possible inclusion under the film of a bubble of air. This is easily expelled by allowing a thin stream of water to gently dribble from a tap upon the film behind the bubble, and gradually moving the plate under the stream of water, which will push the bubble forward till it makes an exit at the edge of the film.

In conclusion, we may say that the process is far easier in practice than the description may appear on paper. For example, a title may be copied, developed and transferred, and the negative dried in less than half an hour. We can recommend our readers to try for themselves, and they will be gratified with the ease and simplicity of the process.—The British Journal of Photography.

WHOLESALE DEVELOPMENT.

MANY, no doubt, have already returned from their annual outing, and many others will soon be back from the four quarters of the globe, bringing with them the, as yet, invisible results of their modest two or three dozen, or their more ambitious two or three hundred, or perhaps five hundred, or even a thousand, time exposures or snap shots, and the problem of exposure makes way for the problem of development. How can these plates be most expeditiously turned into satisfactory negatives?

Not a few, doubtless, regard the pleasure of development as little, if at all, inferior to the pleasure of work in the field. They are in no hurry to get it over, but love rather to take it easily, getting a second trip, as it were, out of it. For such this article is not written. Neither is it meant for the wildly enthusiastic snapshotter who comes home with scores upon scores of his flings at Fortune, and knows no rest, and little food, until he has developed the lot. To a large number, at any rate, a reasonable degree of expedition in development is important. Their spare time may be very limited, or they may wish to make immediate use of the negatives, or they may shrink from the discomfort and trouble occasioned by the icy coldness of the water supply in winter.

We propose, therefore, to indicate briefly for the benefit of those who are new to this sort of work a general method of procedure which we have lately found to work satisfactorily when developing in a limited time between one and two hundred exposed plates.

Some were whole plates, but the majority were quarters, and it is obvious that the same methods are applicable to both, except that progress will necessarily be somewhat slower the larger the plates, even if only by reason of the large area of table space that the dishes take up. It is, in fact, one of the advantages of small plates that they lend themselves to expeditious development if need be.

To develop several plates at once is the obvious way of making the best of the time, and is the common practice in studio work. There are, however, various ways of doing it. In studio work, the exposures have probably been timed with fair accuracy, and the character of the subjects and of the result desired is fairly uniform, and this is true in a different way of snap shots, although variations in the amount of exposure will be greater and more frequent. In either case, however, it is probable that development may be allowed, in the main, to take care of itself, and several plates can be developed in one dish. The conditions are, however, very different when we are dealing with the results of outdoor work, when the subjects may be of the most varied character, the nature of the results that we wish to obtain may be equally varied, and the exposures may be more or less uncertain. We are obliged, therefore, to adopt a plan which will give us reasonable rapidity of working combined with the maximum possible degree of control. For work of this kind, while we develop several plates at once, we keep each one in a separate dish. When developing with pyro-ammonia we find that four quarter plates is as many as we can safely deal with at once, though with the more slowly acting pyro-soda it may be possible (we doubt whether it is advisable) to have more going at once.

With the slow plates which we generally use pyro-ammonia is our common developer, though we always have some metol developer ready at hand for use when the character of the subject makes it desirable to have a negative with a bluish color. For rapid plates pyro soda seems, on the whole, to be preferable.

Pyro is most conveniently kept in the well known 1 in 10 solution, with potassium meta-bisulphite (also 1 in 10). For the alkali and bromide, when a lot of plates have to be dealt with, it will be found advantageous to make up in considerable quantity a solution containing

Ammonia 0·880	6 parts.
Ammonium bromide	4 "
Water up to	100 "

It will be seen that this is readily done by mixing sixty parts of the ordinary 1 in 10 ammonia solution with forty parts of the 1 in 10 ammonium bromide solution. The proportion of ammonium bromide given, though higher than usual, is not high enough to appreciably increase the time of development, while it is high enough to prevent general fog with most plates that can be developed with ammonia at all, which is more than can be said of the proportions of bromide commonly recommended. Good plates will stand from 80 to 100 minims of this solution in each fluid ounce of developer.

A convenient method of work is to mix up first of all enough developer to serve for four plates, keeping part of the alkali back, however. The plates are then put into the four dishes, the developer poured over, and the operation proceeded with in the usual way, more of the alkali mixture being added if necessary. An ammonia solution, 1 in 10, and an ammonium bromide solution 1 in 10 should be at hand. As each plate is finished it is well rinsed with water, and either kept for a time in the same dish or transferred to a large dish capable of holding all four plates.

Although we regard it as inadvisable to develop several plates in one dish, it is very convenient and saves a great deal of time to fix several plates in one dish and give them their first washing after fixing in the same dish. For this purpose the papier mache or celluloid dishes that can now be had divided into four compartments are very convenient. The four developed plates are put into a dish of this kind, and the necessary quantity of hypo solution is poured in from either a jug or a porcelain dish. When the plates are fixed, the hypo solution is poured back into the aforesaid jug or dish, and the plates, remaining in the dish in which they were fixed, are given a good washing by means of water from the tap, an India rubber tube bringing the water down close to the dish.

Two of these partitioned dishes are necessary, so that a second batch of plates can be fixed while the first batch is having its first washing. By the time the third set of four plates is taken in hand the position of things will be: First four, washing in partitioned dish No. 1; second four, fixing in partitioned dish No. 2; third four, developing (in separate dishes). When the third four are developed, the plates in the partitioned dish No. 1 are transferred to the rack in the washing tank, and the dish is ready to receive the third set of four plates for fixing.

With pyro-soda developer the procedure is just the same, and three or four dozen plates can be developed, fixed and washed in comparatively little time, though, when we get up to whole plates, progress is slower, because the use of partitioned dishes becomes almost impracticable.—C. H. B., Photography.

A TERRIFIC BALLOONING EXPERIENCE.

THE Berlin Vossische Zeitung publishes further particulars of the wreck of the balloon Jupiter. M. Boiteux, one of the aeronauts, says:

"When we had risen 600 yards or more, we found ourselves in such thick clouds that we could distinguish nothing. Suddenly the Jupiter lay on one side and the car leaped terribly. At the same time we were lashed by large hailstones and heavy rain. We were driven forward with bewildering speed. In our fright we threw out everything that our hands came across. The balloon sprang upward like an arrow and soon passed through the clouds. We were under a clear sky, in the light of the setting sun. Gradually it grew colder and colder, and our wet clothes were frozen stiff. Crepillon fell fainting to the bottom of the boat, and we others were not much better off. We were all bleeding, for the hail had wounded us. As I looked out I saw a large black cloud moving from southwest to northeast. But we still rose. Then I saw nothing more. The blood streamed from my nose and ears. My hands were frozen hard as a board.

"In a few minutes we had risen to a height of nearly 5,000 yards. Then we began to sink, first slowly, then rapidly. All at once we were again in complete darkness. We were in the midst of thunder clouds. Again, amid hail and rain, the wind drove the Jupiter on at a speed of ninety miles an hour. We were blinded by the hail and could scarcely breathe. But I did not lose hope of reaching the earth safely. The hail and rain now began to be mixed with leaves and particles of earth. The car was violently shaken, and we fell against each other, and had to hold on to the ropes. Then we began to drag along the ground. The balloon suddenly rose again. I let my rope go, and was dashed to the ground. Legrand believed that I had voluntarily jumped out. He jumped after me, and fell near me with a broken leg. Thus lightened of weight the balloon rose more rapidly. Rushing through the tree tops, it went on about six miles in the direction of Gretz. As it hung on the top of a tree Foucard tried to land, caught a rope, but was thrown violently to the earth. A woman saw the balloon hanging in the trees and sent the people at her inn to our assistance. Foucard was found covered with mud and ice, his face all torn. He still breathed. When his head was raised with the intention of giving him stimulants, he was seized with a convulsion and soon expired.

"As he was carried away a weak voice was heard calling from the car for help. Two ladders were brought and tied together, and a gendarme climbed up to assist Crepillon. It took an hour to get him down. On reaching the ground he fainted away. He was cold as ice, and only regained his senses after continued friction. In a few hours he was out of danger."

Preservation of Mucilage with Acetanilid.—According to M. Kellar (L'Union Pharm.), acetanilid is an admirable preservative of acacia mucilage. For this purpose he uses it in the proportion of about 1 grain to each fluid ounce of the product.

SELECTED FORMULÆ.

Etching on Glass.—Hydrofluoric acid, when applied in its pure state, produces such a smooth corrosion of the glass that it may elude superficial inspection, so, in order to produce a visible effect, other expedients must be resorted to. The most common method consists in mixing ammonium fluoride with precipitated barium sulphate and decomposing with sulphuric acid. Such a preparation has been, and may now be, sold under the name of "diamond ink." A formula for this was published some years ago in the American Journal of Pharmacy, and is as follows:

DIAMOND INK.

Ammonium fluoride	10·0
Barium sulphate	30·0
Sulphuric acid	enough

Rub the two solids together, transfer to a platinum, lead or gutta percha vessel, and add sufficient sulphuric acid to produce a creamlike paste. Operators must be cautioned against inhaling the exceedingly acrid vapors of hydrofluoric acid. Apply with a quill or camel's hair pencil.

For the sake of variety we select from various sources a number of other formulas.

GLASS ETCHING SOLUTION. NO. 1.

Ammonium fluoride	10·0
Barium sulphate	10·0
Hydrofluoric acid, fuming	enough

Proceed as in the foregoing, enough acid being used to decompose the ammonium fluoride.

GLASS ETCHING SOLUTION. NO. 2.

Ammonium fluoride	10·0
Barium sulphate	30·0
Water	enough

This is made into a semiliquid mixture and may be applied with a common pen.

GLASS ETCHING SOLUTION. NO. 3.

Sodium fluoride	0·72
Potassium sulphate	0·14
Water	240·00

Make and add to the foregoing another solution consisting of

Zinc chloride	0·28
Hydrochloric acid	40·00
Water	40·00

At the end of half an hour the design should be sufficiently etched.

GLASS ETCHING SOLUTION. NO. 4.

A mixture is made of ammonium fluoride, sodium chloride, and sodium carbonate, and then placed in a gutta percha bottle containing fuming hydrofluoric and concentrated sulphuric acids. In another lead vessel potassium fluoride is mixed with hydrofluoric acid, and a little of this solution is added to the former, along with a little sodium silicate and ammonia. This solution, patented in Germany, by Meth & Kreitner, may be used with a rubber stamp.

The following two recipes obviate the use of expensive fluorine salts used for opaque glass etching:

GLASS ETCHING SOLUTION. NO. 5.

Hydrofluoric acid, dilute	c. c.	0·50
Hydrochloric acid	"	0·50
Potassium sulphate	g.	0·50
Potassium carbonate, c. p.	"	1·33
Water	c. c.	4·00

Mix the foregoing, and then treat with concentrated hydrofluoric acid and potassium carbonate until the mixture produces the requisite degree of opacity.

GLASS ETCHING SOLUTION. NO. 6.

a.—Potassium carbonate	10·0
Water, warm	20·0
b.—Soda	10·0
Water, warm	20·0
c.—Potassium sulphate	10·0
Water	10·0
d.—Hydrofluoric acid, concentrated	20·0

Mix a and b, then add d, and lastly c. The addition of a small quantity of hydrochloric acid gives a fine granulation to the etched surface.

In order to render etched lettering more visible, various pigments are rubbed in, or asphalt varnish may be applied.—Western Druggist.

Soothing Liniments.—In the Journal des Praticiens, for August 15, a writer says that for this class of medicaments the indications are numerous, slight attacks of neuralgia, local pains during the course of general affections, and various forms of arthralgia being the principal ones. He recommends the following formulæ:

1. Wine of opium	30	grains.
Chloroform	120	"
Oil of chamomile	300	"
2. Hydromel of opium	30	"
Chloroform	60	"
Oil of hyoscyamus	450	"

If these prescriptions are disagreeable to the patients on account of the oil, the following liniment, which is attributed to M. Gingeot, may be substituted. It is not greasy, it produces a sufficiently intense revulsion, and gives good results many times where other liniments have failed.

Fioravanti's balsam	225	grains.
Camphorated alcohol	225	"
Hydromel of opium	150	"
Tincture of belladonna	150	"
Oil of turpentine	75	"
Chloroform	75	"
Acetic ether	75	"

Photographic Flashlight Powder.—At the Antwerp section of the Belgian Photographic Society it was stated by M. Ommeganck that a satisfactory flashlight powder can be prepared by well rubbing together in a mortar five parts of magnesium dust, three parts of aluminum dust, and one part of red or amorphous phosphorus. This preparation is said to give a more rapid flash than simple magnesium or aluminum dust, while free from the danger attending the use of explosive mixtures containing potassium chlorate.—Amateur Photographer.

ENGINEERING NOTES.

Shipping at Hamburg amounted to 6,256,000 tons in 1895, while Liverpool has only 5,965,959 tons to its credit for the same year. In ten years Liverpool's shipping has increased about 40 per cent., while Hamburg's shows an increase of about 70 per cent.—Uhland's Wochenschrift.

The railway from Vossevangen to Taugevand (Norway) has a length of 74½ kilometers, with a difference of 1,250 meters in the altitudes of the terminal points. It also includes a tunnel of 5,300 meters length at an altitude of 860 meters. This railway will form a section of the important line Bergen-Christiania.—Uhland's Wochenschrift.

By the building of the last stretch of railroad between Naples and Reggio the line along the west coast of Italy has been completed. The construction has been very costly, there being a hundred bridges of some length and eighty-two tunnels, two of them three miles long, two two miles, and fifteen more of over half a mile. Just below Scylla the cars are ferried across the Faro to Messina, where they connect with the Sicilian roads.

A practical use for the ground occupied by the picturesque ruin of the Cour des Comptes on the Quay d'Orsay has been proposed to the French government. The Orleans Railroad wishes to transfer its main station there and to utilize it as a station for the underground and belt railroads as well. This plan would bring the railroads running into Paris from the south as close to the heart of the city as those from the north are brought by the Gare Saint Lazare, and would give them a temporary advantage, as the station would be at the gates of the 1900 exhibition grounds.

Preparations are being made by Chicago citizens south of Eighty-seventh Street for the creation of another sanitary district. The plan of Mr. Jocely and those associated with him is to build a channel connecting with the Calumet River at Blue Island and striking the Chicago drainage canal at the Sag, a distance of eight or nine miles from Blue Island. It is proposed to widen and deepen the old Illinois and Michigan Canal feeder, taking what is known as the Stoney Island Creek route. It is estimated the canal will cost $4,000,000 or $5,000,000. Eventually it is expected that the Calumet River will be widened and deepened and that vessels can pass through to the main canal at the Sag.—Chicago Times-Herald.

The total length of railways open for traffic in India on March 31 last was as follows, says the Engineer: State lines worked by companies, 8,979¼ miles; state lines worked by the state, 5,742¼ miles; lines worked by guaranteed companies, 2,587 miles; assisted companies, 107½ miles; lines owned by native states and worked by companies, 858½ miles; lines owned by native states and worked by state railway agency, 164¼ miles; lines owned and worked by native states, 898¼ miles; and foreign lines, 58¾ miles, giving a grand total of 19,677¾ miles. At the end of the previous corresponding year the grand total mileage was 18,855¼. The total working expenses of the Indian Railways in 1895 amounted to 12,11,98,860 rupees against 11,98,39,200 rupees in the previous year, and the net earnings realized were 14,11,70,200 rupees against 13,52,49,364 in 1894.

The French Minister of Railways has issued his annual report for 1895, showing the development of the railways of France last year, from which we learn that the railway net of the six principal or trunk systems was but slightly increased, viz., only by 89 kiloms., of which 30 kiloms. were furnished by the Lyon, 28 by the Nord, 15 by the Ouest, 8 by the Est, 6 by the Midi, and 2 kiloms. by the Orleans railway. This addition of 89 kiloms. brings the total lengths of the French trunk railway system up to 36,595 kiloms., of which 32,281 kiloms. are owned by the great companies named, 1,084 kiloms. by the secondary companies, 2,631 kiloms. by the state, 342 kiloms. by non-concerted concerns and 227 kiloms. by industrial companies. Nor do the local or departmental lines show much progress, the new lines opened last year only covering 141 kiloms.: Meuse, 38 kiloms.; Oise, 27 kiloms.; Ardennes, 12 kiloms.; Nord, 7 kiloms.; Seine et Marne, 1 kilom.

Some experiments made at the engineering laboratory of the University of Michigan to determine the strength of welded joints are especially interesting, says the Engineering and Mining Journal. Of a number of the specimens tested, not one broke in the weld; as some of these were slightly larger at the weld, a new set of specimens was prepared and a cut taken from each in the lathe to reduce the piece to a uniform diameter throughout its length between the jaws of the testing machine. Common round iron was used. Three bars were taken at random, 1¼ in., 1 in. and ¾ in. in diameter. From each bar four specimens were prepared, one solid, one lap-welded, one butt-welded and one split-welded. The results show that only two specimens, both lap-welded, broke at or near the weld; the fracture in one case was slightly crystalline and in the other fibrous. The strength in no case departed widely from the strength of the solid parts. It would seem from these tests that with skillfully made welds we may expect to realize nearly the full strength of the original bar.

In a comparison made by Prof. R. H. Thurston of the relative strength of metal and timber, cast iron, he states, which weighs 444 pounds to the cubic foot, will sustain in a one inch square bar a weight of 16,500 pounds; bronze, weight 525 pounds, tenacity 36,000; wrought iron, weight 480, tenacity 50,000; hard "struck" steel, weight 490, tenacity 78,000; aluminum, weight 168, tenacity 26,000. In comparing equal weights of wood and metal the latter does not always prove the stouter, the instance being cited of a bar of pine just as heavy as a bar of steel an inch square and holding up 125,000 pounds, the best ash 175,000, and some hemlock 200,000 pounds. The best steel castings made for the United States Navy are rated at a tenacity of 65,000 to 75,000 pounds to the square inch. By solidifying such castings under a great pressure, Whitworth got a tensile strength of 80,000 to 150,000 pounds. Fine steel wires and ribbons from ingots give a tenacity of 300,000 pounds to the square inch of cross section. Ordinary aluminum is only one-third as heavy as steel; a bar of it, with a square section of three inches, will hold up 78,000 pounds.

ELECTRICAL NOTES.

The first electric tramway constructed in Egypt was opened at Cairo, Egypt, on August 1.

It is said that a plant of the Thomson-Houston type for the electric annealing of armor plates is about to be erected by the French government at Cherbourg.

In Richmond, Virginia, a regulation has been put in force according to which any current leakage from electric tramway lines will be taken as sufficient evidence that corrosion of the gas and water pipes is being caused by the electric railway company.

It would appear, judging from the report of the Committee on Electrical Standards, appointed by the British Association, and which has had under consideration a thermal unit, that some multiple of the erg should be adopted as the theoretical unit, but there are differences of opinion as to the multiple to be chosen. There is a fairly general agreement that as a practical unit the heat required to raise one gramme of water one degree Centigrade must be taken, but views differ as to the initial temperature of the water.

The telephone cable by which Mr. Preece intends to connect England and Germany at no very distant date has eight conductors of semicircular section, and grouped in four pairs, separated from each other on the flat sides by a very small distance. They are insulated first with paper and then with gutta percha, the paper only existing between the conductors. The cable is sheathed and compounded in the usual form, but there are four circuits instead of two, as at present in the London-Paris cable.

The dwelling at 5 West Twenty-second Street, New York City, possesses much interest to the telegraphic fraternity, says the Electrical World. In it Prof. S. F. B. Morse, the inventor of the telegraph, lived for many years and died, these facts being permanently recorded on a white granite slab, which is embedded in the front of the building. The premises are now unoccupied, but are looked after by a caretaker, and it is stated that they will soon give way to a modern business structure. A tree and vines in the area are silent reminders of its famous former occupant, under whose orders they were planted. A one story extension was used by Prof. Morse as his library, and the same shelves used by him still remain, but they are vacant.

A number of railroads in the United States are contemplating placing electric headlights on the locomotives in place of the present headlights, but Theodore N. Ely, chief of motive power of the Pennsylvania Railroad Company, in speaking of the use of the electric headlight, said that the Pennsylvania Railroad experimented with this system several years ago, and, while it gave an excellent light, it would not answer the requirements, as on a two track or a four track road the rays from the locomotive coming in an opposite direction were so strong as to blind the engineer, and it would be some time before he got over it. Mr. Ely also said that of late years they have been reducing the size of the headlights for the locomotives. They were formerly thirty inches, but are now sixteen. Headlight oil, he thought, was more reliable and cheaper.

The American consul at Copenhagen reports to the State Department that a young boatswain in the Danish navy has invented a telegraphic apparatus for communication with a ship at a certain anchorage without the use of a direct line. An electric battery, with one pole in contact with moist earth at one end and a telegraphic key and interpreter at the other, constitute the Bland apparatus, from which a cable is laid to and around the anchorage in a coil from 1,000 to 1,200 feet in diameter. A solenoid connected with a telephone aboard the ship completes the apparatus. The plan has worked successfully, and the young inventor is now at work to get rid of the telegraph key and make the communication wholly telephonic. Among the advantages of the new method is that signals made in this manner will not be visible to an enemy, as in the case of flags, and that ships moving near the shore can communicate with stations while passing over certain spots before designated.

The medical officer of one of the leading deaf and dumb institutions of England, writing to the London Lancet, says that he has obtained material aid from the seeming improbable source of a loud speaking telephone in the treatment of his patients. In the education of those deaf mutes who possess a fragment of hearing power the telephone possesses many important advantages over the speaking tube usually employed. First and foremost, the wires from several receivers can be coupled up to one transmitter, and thus a teacher can instruct a group of children at the same time; and, secondly, it is not necessary for the teacher to apply his mouth close to the transmitter, so that pupils have a full view of the facial expressions and lip movement, which is not possible when he has to direct his voice into the mouthpiece of a speaking tube or trumpet. The patient, while seeing the movement of the lips, has the sound conveyed close to his ear drum—obviously a most advantageous combination.

The Japan Weekly Mail states that the Japanese government, with the consent of the Diet, is to appropriate a sum of above 12,800,000 yen, spread over seven years, for the expansion of the telephone service. The work of construction is being now actively carried on at various important places, the present intention being to complete, by March, 1898, the contemplated expansion of the service in so far as concerns Tokyo, Osaka, Yokohama, and Kobe, as well as the new constructive work in Nagoya, Nagasaki, Shimonoseki, and so forth, and to establish connection between Tokyo and Kobe. According to estimates for the current fiscal year, the number of new subscribers in the four cities of Tokyo, Yokohama, Osaka, and Kobe, under the expanded system, will be 13,333, and of those in Kyoto, and thirty-five other places, where the service is to be newly established, there will be 6,800. Side by side with the erection of telephones in so many places, the authorities will also effect various junctions between places already furnished with telephones. For instance, a connection between Tokyo and Kobe will be established via Osaka, Kyoto, Yokkaichi, Kuwana and Nagoya. It is feared that this portion of the work may not be completed within the prescribed period.

MISCELLANEOUS NOTES.

Leprosy is slowly but steadily spreading in the district of Memel, in East Prussia, some of the patients being very young. As the disease seems to be chronic and indigenous, the government is about to establish a leper asylum there.

When Paris dedicated a short time ago the Ecole Etienne as a training school for printers, naming it after the great French printers of the early sixteenth century, Henri and Robert Etienne, there was present at the ceremony a Henri Etienne, thirteenth in lineal descent from Robert. He is a working printer, like every one of his ancestors.

During the existence of the British Parliament it has passed about 20,000 statutes, of which about 5,000 are still in force. Of these 3,300 were passed in Queen Victoria's reign, 151 date from Henry III, the first three Edwards and Richard II, 25 from the house of Lancaster, only 3 from that of York, 170 come from the Tudors, 69 from the Stuarts, 92 from William III and Anne, and 1,132 from the four Georges and William IV.

The second log raft to successfully make the trip down the coast has reached San Francisco. As in the case of the one taken down a year ago, the weather was exceptionally favorable, as the ocean has been like a mill pond for weeks. Inasmuch as there are only rare periods when the waves are harmless, the success of this method of transferring timber is as yet rather limited. Two rafts have been lost and two have gone through in safety. A system that necessitates waiting a year for a favorable chance to operate it can hardly be called a success.

A large body of short fiber asbestos was discovered some time ago in White County, Ga., U.S.A. The asbestos rock in this body is about 350 ft. wide, 950 ft. long, and as far as known, 60 ft. deep. The material in this rock is not adapted for textile fabrics but is especially valuable for paper pulps, cement and for bricks for lining furnaces, heaters and grates. The bricks can be cut directly from the rock. For other purposes the rock needs only to be milled, no separation being necessary, on account of its almost absolute purity. The analysis of the rock shows about 50 per cent. silica and 30 per cent. magnesia.

A Japanese soldier is allowed seven ounces of meat in his rations, an Austrian or Spanish private eight, a French, Turkish, German, or Belgian nine, an Italian eleven, an Englishman twelve, a Russian sixteen. The ration in the United States army is twenty ounces. The ration of bread is highest in the Austrian army, thirty-two ounces, and lowest in the English, sixteen ounces. In the German army it is twenty-eight ounces, in the French and Italian it is twenty-two, the same in the United States, and in the Russian army seventeen ounces. All modern armies, save the Russian, have also a daily allowance of rice.

The country practitioners in Austria complain that the fees which they receive are too small, and one of them has proposed the following scale (the equivalents being given in American money): Office visit, 15 cents; first visit to patient's house, 30 cents; subsequent visits, 25 cents each; night calls, 60 cents; setting a fracture, $2.25; major surgical operations, such as amputations, and the like, from $6 to $9; hypodermic injection, 20 cents; antitoxin injection, 80 cents; bacterioscopic examination, 80 cents. The prizes of the profession do not seem to lie in Austria.—Medical Record.

A patent has just been granted to Mr. C. S. Hirst, of Philadelphia, Pa., for a novel method of preserving oysters, clams, etc., retaining their liquors and juices so that when opened they will be found good and healthy. This is accomplished by keeping the shells of the bivalve fastened together by means of small plugs of wood which are driven through the outer edge of the shell at a point opposite to the hinge. The plug passes through perforations in the shell and then absorbing the juices of the bivalve swells so that the shells are held tightly closed and the oyster is hermetically sealed. The plug is not likely to be knocked out during transportation, and the plug may be removed with the breaking of the shells for the insertion of the knife. The idea is a novel one and may result in increasing the market for the popular bivalve.

M. G. Deniges, of Bordeaux, having obtained possession of three samples of yellow powder used by certain milkmen at Bordeaux to preserve their milk, made a chemical analysis of it. This analysis showed that two of the powders were composed wholly of neutral chromate of potash, that the third was a mixture of one part of bichromate of potash and two parts of neutral chromate, and that the suspected milk had been adulterated with the last substance in the proportion of 0·30 gm. to the liter [5 grains to the quart]. The alkaline chromates are, in fact, powerful antiseptics, capable, even in small quantities, of retarding lactic fermentation very noticeably, if not of stopping it completely. But because of the pernicious action of these salts on the organism they ought to be completely excluded from food substances, and particularly from milk, of which many young children drink relatively large quantities.—Review Scientifique (Paris).

Decorative artists are naturally interested in the description of a novel process of painting recently brought to notice by a Swedish genius, Mr. Swen, of Gothenburg—a process which, it seems, renders it possible to adorn plate glass with artistically executed paintings in such a way as to serve as panels for furniture or as articles of tasteful ornament. To so high a degree of beauty, in fact, has this curious application of coloring been carried that specimens exhibited at Berlin by the originator are said to have excited great attention. By a method peculiar to Mr. Swen the employment of phosphorescent matter in the colors produces a glowing brilliancy, which, in semi-darkness or entire obscurity, illumines these panels with a glowing light of singular attractiveness. As represented, this kind of painting is not only fadeless, but, being protected by the plate glass, is indestructible. Glass plates of this decorative character are by experts pronounced much preferable to majolica tiles, on the score of beauty and durability.

THE BICYCLE IN THE ARMY.

Although silent upon the road, the folding bicycle has, nevertheless, been making much noise in the world for some time past. It is spoken of with approval and is everywhere under experiment—in Europe, Asia and America. In the Russian army it is the order of the day. Gen. Plioutzensky has just devoted an interesting paper to the demonstration of its multiple military applications, and he thinks that the time has come when tactics appropriate to this new war machine should be devised.

Our minister of war has not been willing that other nations should get ahead of us. We have, moreover, made up for lost time, as regards military cycling, through Capt. Gerard's invention. Gen. Billot, in view of the approaching grand maneuvers, confided to that officer the mission of forming a company of fighting cyclists. The results obtained in the first trials at the school of Joinville-le-Pont seem to be a guarantee of the success of the experiments that are to come.

Our engravings show the fighting wheelmen in some of their exercises. First we have the company on the march—the united swarm of "flies of war" advancing without any buzzing to expose it. At its head pedals Capt. Gerard flanked by Lieutenants Clabault and Picard. Scarcely any noise is made in the smooth rolling, which transmits no vibration to the ground, where a squadron of cavalry would betray its presence a long time in advance through the noise made by the horses' shoes.

Again, we have the cyclists in fighting array; for it must not be forgotten that they are combatants. In their exploring service they have just fallen upon a reconnaissance of the enemy's cavalry. It is necessary to fight the thing out, and so arrangements are immediately made to do so. Their machines between their legs, the cyclists prepare to receive the cavalrymen with a well directed fire. If the fusillade does not arrest them, the horses will get entangled and break their legs in the network of wire that the bicycles oppose to them.

Next, we see the cyclists changed from riders to foot soldiers after the order: "Machine upon the back." With their folded bicycle, which is lighter than a knapsack, they experience no constraint in their motions and in the maneuver of their weapons.

The cavalry, which is at once the eye, the mask and the buckler of the army, will have much to suffer from the improvement in modern weapons. One of its functions is to discover the enemy. Smokeless powder will render it more difficult for it to do this. Before discovering the enemy, it will itself be perceived and receive shots without knowing whence they have been fired.

Capt. Gerard's machine, which is rapid, noiseless and non-cumbersome, permits the cyclist to utilize the accidents and coverts of the road, such as ditches, bushes, walls, rocks, etc., without halting. He remains concealed where the presence of the cavalryman would be betrayed by the noise of his horse's shoes. Capt. Gerard's truly original idea is to have the man carry the steed when the latter can no longer carry him. Moreover, the inventor has introduced into his machine some important improvements that respond to the exigences of the military service. The folding bicycle is safe, light, easily carried or housed, and the handling of it is quickly learned. The fear of falls is suppressed and the machine is immediately stopped at will. The rational position of the cyclist, who is seated over the hind wheel, satisfies the prescriptions of hygiene and suppresses the ungraceful and distorted attitude that is assumed by some wheelmen, who bend forward over their machines like jockeys upon their horses.

If the folding bicycle keeps all its promises, it will be able, as a war machine, to be compared with the fly of the fable. The lion will be the enemy, disdainful at first, but soon put upon the defensive, and finally conquered by the sorry insect that has tormented it without truce or mercy.—L'Illustration.

A COMPANY OF BICYCLISTS ON THE MARCH.

INFANTRY CARRYING THE BICYCLE.

BICYCLISTS IN BATTLE ARRAY.

According to the Papier Zeitung two Vienna inventors, Messrs. Theyer and Hardmuth, have applied themselves to the manufacture of an envelope in which letters shall be secure from photography by the Roentgen rays. The X ray proof wrapping so far most approved is of heavy paper with a lining of bronze. Another form has bronze ornaments on the outside so closely placed as to protect the letter within. The coating of bronze, electrically deposited, is extremely thin, and but little heavier than the paper.

RENAISSANCE CLOCKS ACCORDING TO WORKS OF ART.

THE clocks of the sixteenth differ from those of the preceding century in the fact that in their external form and the form of their movements they followed the diverse whims of the artists, who at that period no longer took into consideration the tradition in which the old clock, properly so called, was preserved, but the manufacture of which was, nevertheless, continued in slightly modifying its external decoration. In Fig. 1 we give a reproduction of a painting by Paul Veronese representing a woman holding a clock in her hands, and in Fig. 2 twelve different styles of clocks. The clocks of which we speak have furthermore, as peculiar characters, a copper case more or less engraved or chased and a striking train inclosed in a dome or campanile. These pieces were either placed upon some article of furniture or were suspended, but their destination in nowise influenced their form or the richness of their ornamentation. They were the same, whether they were actuated by weights or springs.

Why these clocks, when they were suspended and consequently quite far from one's sight (since considerable height was necessary in order to give play to the cords), were as freely decorated as those placed upon pieces of furniture would not be understood did we not reflect that the rich, who alone possessed them, insisted that they should be made in the new style which this wealth of ornamentation precisely characterized. The difficulties that were met with at this epoch in the manufacture of springs and the poor results obtained from the latter often caused weight-moved clocks to be preferred.

We have just said that the motor in no wise changed either the form or the proportions of the Renaissance clock. In fact, that of Henry VIII of England (1509-1547) was a clock with weights, and its external structure, as well as its ornamentation, was as rich in details as were the finest portable timepieces that we shall describe further along (Fig. 2, No. 1).

In the sixteenth century, we find clocks whose weights were inclosed in the case, just as in the regu-

FIG. 1.—WOMAN HOLDING A CLOCK IN HER HAND.

(From a painting by Paul Veronese.)

lators of the eighteenth century. In Fig. 2 (No. 2) is shown a clock that is held in the hand by a statue in the funereal monument of Cardinal Hemart, Bishop of Amiens from 1538 to 1540, and which is found upon one of the pillars of the cathedral of that city. We shall classify the principal forms of the clocks of the Renaissance having cubical cases, in taking their summit, which is generally very interesting, as a guide. We shall make four great divisions: (1) The hemispherical dome; (2) the surbased dome; (3) the campanile; (4) various conceits.

(1) Hemispherical Domes.—The oldest document in this line in our possession dates back to 1508. It is in a tapestry whose subject is entitled the Road of Honors that we find it represented. The clock is rich in ornamentation and the dome is in open work.

The Sfner Book of Costumes (1543) reproduces one ornamented with pilasters at its angles. It is of a somewhat heavy aspect.

In a painting by Titian (1477-1576) at Madrid, representing a knight of Malta, we observe near him, upon a table, a Renaissance clock with a hemispherical dome and whose four angles are ornamented with cylindrical columns that rest upon balls and are surmounted by vases. The architecture of this piece is remarkable. It is ornamented in all parts with engravings.

By the same painter, at Florence, there is a portrait of the Duchess of Urbino, near whom there is a table upon which stands a clock with a dome (Fig. 2, No. 3). This piece is enriched with engravings, and ornamented with pillars at its angles. At the top, upon a small platform, there is a statue of Hercules. A figure was often placed at the apex of Renaissance clocks, and this practice was continued during the following century.

At the National Gallery of London there is a portrait of an apostolic pronotary painted by Lorenzo Lotto, and near him a very beautiful clock with a hemispherical dome.

(2) Surbased Domes.—The Renaissance clocks with surbased domes were as a general thing the richest. One of the pieces formerly belonging to the collection of Prince Soltykoff, and dating back to 1521, was provided with a dome which was truly superb as regards composition and execution. The subjects represented the Annunciation, the Nativity, the Kings and the Holy Family. The four angles of the dome were ornamented with dragons upon which were seated men armed with a sword. A knight representing St. George, clad in brilliant armor, and figures in half relief were applied to the faces and particularly to the face of the dial.

One of the most celebrated of these pieces was that constructed by Jaspar of Bohemia, and which he ostentatiously signed: "Me fecit Chasparus Bohemus in Viaenna Austria, 1568." Speaking of this piece, Charles Yriate says: "It is one of the chefs-d'œuvre of this kind of work. Upon the fluted base decorated with bass reliefs the artist has represented the Triumph of Woman after Hans Sebald Beham. The open work dome represents hunting scenes. It forms part of the beautiful collection of the Schatz-Kammer of Vienna."

This piece was not unique, for the Stein collection possessed a specimen of it that passed into the Spitzer collection, now scattered. The surbased dome in certain pieces has considerable importance and a complicated ornamentation of balustrades and figures that render them very sumptuous. The one represented in Fig. 2, No. 4, is of German origin.

(3) Campaniles.—The clocks of this category are the most numerous and also offer very beautiful types. A picture of Breughel (1568-1621), entitled Hearing, and belonging to the royal palace of Madrid, represents one of very fine aspect and of good proportions. The ornamentation of it is very simple.

Velasquez (1599-1660) painted a portrait of a woman, which is now in Madrid and in which there is a clock (Fig. 2, No. 5) whose campanile consists of a cylindrical openwork base engraved and surmounted by a dome engraved in the same manner. A balustrade, accompanied with pyramids at the angles, surrounds the base. At the angles of the case there are beautiful columns. The whole is supported by crouching lions. This clock, as was frequently the case at the epoch, is placed upon a wooden base.

The campaniles were often composed of small turned balusters offering a very light aspect. The clock that we reproduce in Fig. 2 (No. 6) has three superposed rows of these balusters. It belongs to the Museum of Milan.

(4) Various Conceits.—This denomination, which is perhaps somewhat vague, is nevertheless necessary, since the imagination of the artists created certain original types that cannot be embraced in the other categories.

For example, in a painting by Tintoretto (1512-1590), now in the Hermitage Museum, of St. Petersburg, there is a portrait of a man near whom is a clock carrying a bell and having no ornaments. Other summits have the form of a belfry; others resemble the roof of a house; and others again have the aspect of strong castles with battlements, etc. The most beautiful ones are those in the form of monstances, that is to say, whose movement is placed in a case mounted upon a high stand.

This sort of clocks received superb decorations. We find some with dials complicated with astronomical functions, and whose cases, made of precious metals, rock crystal, gems, etc., are remarkable examples of goldsmiths' work. Figures in high relief also often concurred in their ornamentation. The Spitzer collection possessed one of these pieces in rock crystal and bloodstone, mounted in gold and enamel.

In a painting by Carreno de Mirande (1614-1685), representing Dona Maria Anne, of Austria, there is a table upon which is placed a clock in the form of a monstrance, whose movement is supported by an eagle with outspread wings and surmounted by a royal crown (Fig. 2, No. 7). Simpler ones still have merely a foot with ornaments, like that of the Museum of Cluny. We may also mention, as belonging to the same category, the Calvary clocks, whose dial, under the most diverse forms, was placed at the top of a cross (Fig. 2, No. 8).

The Renaissance alarm clocks (Fig. 2, No. 9), in their vertical arrangement somewhat resemble the pieces called monstrances. They generally consist of two superposed horizontal boxes, one of which contains the hour movement and the other the alarm. The alarm clock then had a period of splendor that it has never since resumed. The princes and great lords possessed them, and that is as much as to say that certain of these pieces must have been sumptuous.

We read in the Gazette Litteraire: "Unpublished

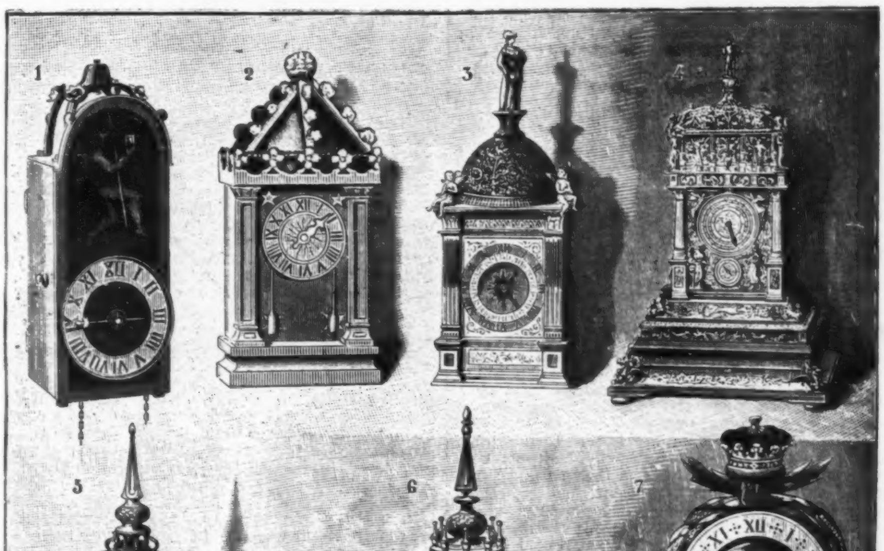


FIG. 2.—1. Painted iron clock of the sixteenth century; Gothic tradition. 2. Clock from a sculpture of the Cathedral of Amiens. 3. Clock with a hemispherical dome; from a painting by Titian. 4. Table clock of gilded copper with surbased dome. 5. Clock with campanile; from a painting by Velasquez. 6. Gilded bronze clock with campanile. 7. Clock in the form of a monstrance; from a painting by Carreno. 8. Calvary clock of gilded bronze. 9. Alarm clock of gilded bronze. 10 and 11. Horizontal clock of gilded wood, with its wooden cover. 12. Italian clock of gilded bronze and ebony.

account of the death of the Duke of Guise Miguet. On the morning of the assassination of the Duke of Guise, at Blois, it was owing to the alarm clock of Du Halde that the king and all his people were able to be up at 4 o'clock in the morning."

In a painting contemporaneous with Christopher Columbus, belonging to a private collection in Madrid, Columbus is represented standing near a table upon which is placed an alarm clock of gilded copper. In most cases, this kind of alarm clock was wholly of metal, but there were some that were of crystal, and the summit was often ornamented with human figures.

From the alarm that we have just mentioned proceed what are known as the Renaissance horizontal clocks.

The geometrical form of the cases of these greatly varied. Some were cylindrical and others square, polygonal, etc. We find one of cylindrical form in a picture by Hans Holbein, entitled "The Merchant," dated 1532. Quite a pretty maxim accompanies it: "No pleasure without sadness." The body of the clock, which is chased, is of gilded copper. Another, belonging to the collection of Mr. Paul Garnier, is of cylindrical form, is dated 1548, and is supported by four tortoises. We find one in another collection that is of rectangular and low form and rests upon four feet in the form of dragons. Some were polygonal and mounted upon feet (Fig. 2, Nos. 10 and 11), with glazed apertures that permitted their movement to be seen. The case inclosing the one that we represent is of wood. Enamel was also employed in the decoration of this kind of clock. We meet with horizontal clocks whose dial is provided with a cover that has as many apertures as there are hours marked upon it. The same idea was applied to Renaissance clocks in the form of books, and the movement of which was placed between the two covers.

There were Renaissance clocks of gold and silver, as in the fourteenth and fifteenth century. In 1601, the Plantin family, of Anvers, received a gold clock as a present from Archduke Albert and Isabella the Catholic. It was a superb piece, and still exists in the museum. It is said to run for three years.

In Prince Soltykoff's collection there was a very beautiful clock, dated 1545, and which had panels of iron inlaid with fine gold.

Rock crystal was also employed in the decoration of Renaissance clocks. In Germany and Italy wood, along with copper, was used in their manufacture. The wood employed was mostly ebony. The clock represented in Fig. 2, No. 12, is of Italian origin. Marble was also employed in the decoration of such pieces.

As we have already said, one of the characters of the Renaissance clocks consists in the engraving and chasing of the case. The engravers of the epoch, who were master decorators par excellence, often represented persons either real or symbolic; but in most cases the ornamentation consisted of foliage or arabesques. In the cast copper and chased pieces there was perhaps no great fineness in the details, although there was great richness in the composition. The repoussé work was often very skillfully treated in the base, panel, and dome.

The first Renaissance clocks with glass placed before the hands date from the extreme end of the sixteenth century. This is found in some of the forms that we have just described.

The dials of the clocks of this epoch were divided into twelve or twenty-four hours, inscribed either upon a single disk or upon two disks, which were concentric and one of which carried the twelve hours in Arabic characters and the other in Roman.

We frequently find an example of a third disk concentric with the two first, and which served as an alarm.

The dial with an enamel disk dates from the sixteenth century, but, as a usual thing, the dials were all of metal, the center and the circumference often being different. Such a piece would have the center gilded and the circumference silvered, or inversely. The center admitted of engravings or even of enamels, and were either translucent or opaque.

The majority of the Renaissance table clocks, with cubical cases, had two dials, one in front and the other behind. The one in front marked the hours with one hand or with two, while the one behind never had but one hand, which was moved by the striking train and advanced only when the latter operated, and according to the number of hours struck. This is why this dial had the hours unequally spaced. Thus, 11 o'clock was very distant from 12, while 1 o'clock almost touched it. In fact, 12 o'clock necessitated twelve strokes, and was, consequently, twelve times the distance from the single stroke of 1 o'clock.

In many table clocks we find small projections formed by the heads of pins or screws placed at the external circumference of the disks opposite each hour. These were designed to indicate the hour by the touch.

The richness of certain astronomical clocks was incomparable, and the decorative details of their multiple functions offered general effects that no kind of dial has since produced.—La Nature.

[Continued from Supplement, No. 1085, page 17347.]

ALTERNATE CURRENT TRANSFORMERS.*

By Dr. J. A. Fleming, F.R.S.

Lecture II.

THE CONSTRUCTION OF THE TRANSFORMER.

In the previous lecture we have examined the general facts connected with the action of the transformer, and we have next to consider questions of transformer construction. The three organs of a transformer being the primary and secondary circuits and the iron core, the constructive problem is reduced to winding these circuits on the core, and properly constructing that core to receive them. We will consider, in the first place, the manufacture of the core. This has to be built up of iron wire or sheet iron, so divided or laminated that eddy currents cannot be set up in it. If it were not for this lamination, the periodic change of induction taking place in the core would set up in the mass of the metal local electric currents which would dissipate energy. Mathematical investigation has shown that, for frequency of 100, or thereabouts, it is useless to make the iron—whether in the form of wire or sheet—less than $\frac{1}{100}$ of an inch in thickness, that is, about one-quarter mm., and useless to laminate it all, unless the laminations are less than 1 mm. in thickness. You will find in the Electrician, vol. 28, pp. 599 and 631, investigations by Prof. J. J. Thomson and Prof. Ewing, which deal elaborately with this matter. I have found that their rather complicated formulae are not fitted for use in the workshop, but that they can, for all practical purposes, be replaced by a much more simple formula, which furnishes all the necessary information for transformer core construction. In the case of good sheet iron, and for the range of induction usually employed in transformer work, which is not more than 3,000 or 4,000 C.G.S. units, that is to say, 30 to 40 microwebers per square centimeter, if we represent the eddy current loss in watts per cubic centimeter of the plates by a symbol, E, and if we call t the thickness of the plate in mils., that is, in thousandths of an inch, and if B is the maximum value of the induction per square centimeter

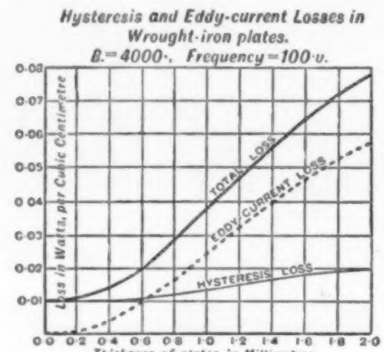
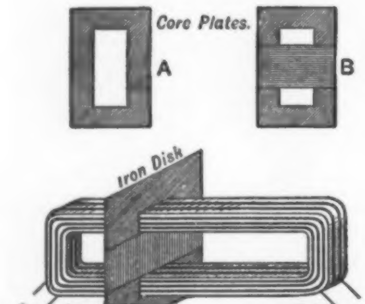


Fig. 25.

in C.G.S. units, and n the frequency, then it can be shown that very approximately $E = \left(\frac{t\ n\ B}{10^6}\right)^2$

Although this is a hybrid formula, containing units of different kinds, and may be horrible to purists, it will, nevertheless, be useful in the drawing office, and we can simplify it still more if we reckon the maximum induction in webers, and call I this induction per square centimeter, then $E = (t\ I\ n)^2$. In some works it is the custom to reckon the induction per square inch instead of per square centimeter, and the thickness of the plate in fractions of an inch. If $t_,$ is the thickness of the plate in inches, and $B_,$ the induction per square inch, and $E_,$ the eddy current loss in watts per lb. of plates, then $E_, = \frac{1·4}{10^{10}} t_,^2\ n^2\ (B_,)^2$. The general custom is to use plates for transformer construction of about 0·014 inch in thickness, and the standard induction which is generally selected is 2,500 lines of induction per square centimeter, or 2,500 C.G.S. units. This is equivalent to 16,125 per square inch. Under these circumstances, by the above formula it is shown that the loss in watts per pound of plates due to eddy currents would be 0·07 watt; the frequency being 100. It may be noted that any increase of temperature as the transformer is worked, by increasing the resistance of the iron tends to diminish the eddy current loss. It will, therefore, be seen that by employing plates of a thickness not greater than 14 mils. eddy current loss is reduced to a very small amount. One point, however, to which your attention ought to be called is that unless the iron plates are properly arranged, eddy current loss may exist in them, however thin they may be. If, either by reason of magnetic leakage, or any



Mordey's Transformer.

Fig. 26.

other disposition of the magnetic induction, lines of magnetic induction move through the iron in such a manner that their direction is not always parallel to the direction of the lamination of the iron, then, under those circumstances, eddy currents may be set up in the core, which are not hindered by lamination. This source of waste was present in many of the earlier forms of transformer. In addition to the loss of energy caused by eddy currents in the core, there is, of course, that other source of loss called the hysteresis loss, which is due to the magnetization and demagnetization of the core, and to the fact that the induction is not in step during the whole period with the magnetizing force, but lags behind it. The investigations of Steinmetz have shown that the hysteresis loss in iron sheets can be represented by a simple empirical formula which fits the facts fairly well. It is found that the hysteresis loss per cubic centimeter per cycle in the iron is related to the maximum value of the induction during the cycle by a simple exponential law, and may be, for all practical purposes, closely expressed by the following formulæ:

Let H = hysteresis loss in watts per cubic centimeter, and H^1 = hysteresis loss in watts per lb., then

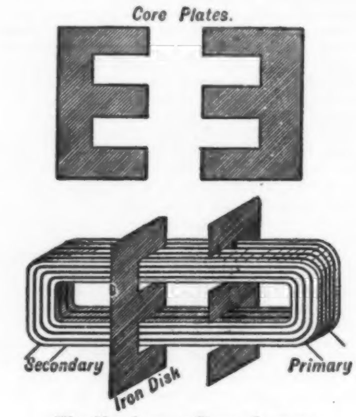
$$H = \eta\ n\ B^{1·65}\ 10^{-7}$$
$$= 0·0032\ n\ B^{1·55}\ 10^{-7}.$$

Where n in the above formula is the frequency, and η is a co-efficient called the hysteretic constant, which depends upon the nature of the iron. The value of η may vary from 0·002 to 0·005. If we reckon the hysteresis in watts per lb., then we have

$$H_, = 0·88n\ (B^1)^{1·55}\ 10^{-9}$$

where $B_,$ = induction per square inch.

The exponential constant may vary from 1·55 to 1·6. Thus, for example, if n = 100, and if $B_,$, the induction per square inch = 16,125, corresponding to induction



Westinghouse Transformer.

Fig. 27.

per square centimeter of 2,500, then $H_,$ = 0·29 watt per lb., and H = 0·005 watt per cubic centimeter. These formulæ have been deduced from experiments made with various kinds of transformer iron; and although they are empirical formulæ, in the sense that they are not deduced from first principles, yet, nevertheless, they are exceedingly useful, and agree so well with experience, that they enable us to calculate the hysteresis loss at any one induction, when we know it at another. We may, therefore, put together the two expressions obtained for the eddy current loss of the hysteresis loss in iron, and state that, for all practical purposes, and within the limits of the induction usually employed in transformers, the total energy loss in the iron, made up partly of eddy current loss, and partly of hysteresis loss, may be expressed as follows:

T = The loss per watts in cubic centimeters;
$T_,$ = The loss in watts per lb.; then

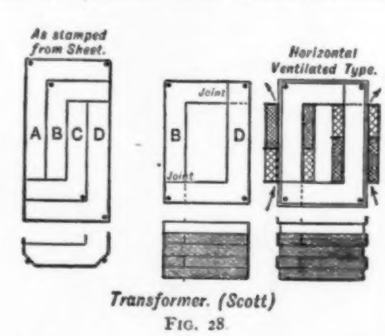
$$T = 0·0032n\ B^{1·65}\ 10^{-7} + \left(\frac{t\ n\ B}{10^6}\right)^2$$

$$T_, = 0·88n\ (B_,)^{1·65}\ 10^{-9} + \frac{1·4}{10·10}(t_,\ n\ B_,)^2$$

Where B is the maximum induction in C.G.S. units per square centimeter, and $B_,$ per square inch.

The curves in Fig. 25 show the variation of hysteresis and eddy current loss in plates of various thickness for a maximum value of the induction of 4,000 C. G. S. units calculated from the formulæ of Prof. J. J. Thomson.

My own experience is that these formulæ agree very well with experience and with the results of measurement. I made, some years ago, a careful study of the old form Ferranti transformers, and found a very fairly close agreement between the results of measurement of the core loss in these transformers and the results obtained by calculation from the above formulæ. In



Transformer. (Scott)

Fig. 28.

specifying for iron for use in transformers, it is now the custom to adopt a standard induction of 2,500 C. G. S. units, or lines of induction per square centimeter; that is to say, the standard induction is 25 microwebers per square centimeter—and the standard frequency is 100. Under these conditions a good transformer iron ought to have a hysteresis loss varying from 0·25 to 0·5 watt per pound. It is possible, under some conditions, to get iron with less hysteresis loss than this, but, as we shall see presently, there are some difficulties in keeping it in this condition. Having selected the iron, the next thing is to stamp out the core plates and afterward to carefully anneal them. It is now well understood that the slightest tooling or handling of iron after it has been annealed hardens it and raises its hysteresis loss—hence the greatest care has to be taken that the plates are not damaged after annealing. The plates have then to be insulated to keep them from electric contact with one another. The old practice was to insulate the plates with thin paper, but paper

* Lecture before the Society of Arts.—From the Journal of the Society.

takes up too much space, and it is now usual to paint the plates with an insulating paint or varnish, which, however, must be able to withstand, without deterioration, the highest temperature which the transformer may reach in work. Even using varnish, the varnish takes about 10 per cent. of the space of the iron. In selecting the iron for the core plates, it is more important to choose an iron with small hysteresis loss than large permeability. These two things are not necessarily connected together. The number of devices which have been adopted for cutting the iron into the core plates, as to avoid unnecessary waste of metal, is very large. In Fig. 26 is shown the manner of building up the core of a Mordey transformer. In Fig. 27 the mode of building up a Westinghouse transformer is also shown. In this case, as in that of the Mordey transformer, where a cross piece is used, or where there are overlapping iron plates, it is customary now to use packing pieces of sheet iron to fill in the levels and to get as much iron as possible into the space. In Fig. 28

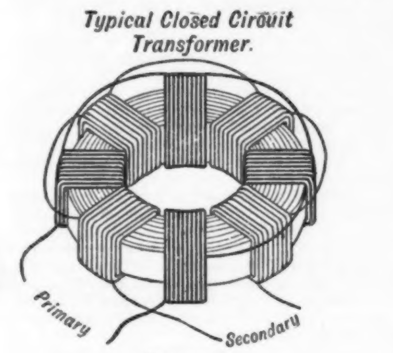


FIG. 29.

is shown the method of stamping the core plates from the sheet and constructing the Scott and Addenbrooke transformer. The iron core having been constructed in such a manner as to afford a completely closed iron circuit for the lines of induction due to the magnetizing force of the primary coil, the core is then covered with shellacked calico and mica in order to insulate it from the primary coil; and the greatest care ought to be taken in this respect, because it is not sufficient to insulate the coils of the transformer from one another; they must both be insulated from the core. The ebonite is often used as a material for insulating the core, and an India rubber compound called woodite is a very good material to use. The primary and secondary coils are generally wound on formers; they must be insulated from each other by ebonite or mica, and the primary and secondary coils should be so overlaid or intermingled (as shown in Fig. 29, which represents a typical closed iron current transformer) to avoid producing magnetic leakage. In large transformers it is customary to leave a space between the high and low tension coils for the purpose of ventilation, and in the same way air spaces or ventilation spaces have to be left in the iron core. The primary and secondary coils are sometimes separated from one another by a metal shielding plate, which is connected to earth. This is, however, not so good a plan as an effectual separation of the primary and secondary coils by an insulating shield. In the design of the core it is important to reduce the reluctance of the magnetic circuit as much as possible in order to produce a large power factor. The term "power factor" is defined as the number representing the ratio between the true power taken up in the core to the product of the primary potential difference and the primary current (root mean square values being understood). This product is called the apparent power taken up in the core.

We shall consider in a later lecture the disadvantages of a small power factor. Meanwhile it may be said that a small power factor in a transformer, when taken

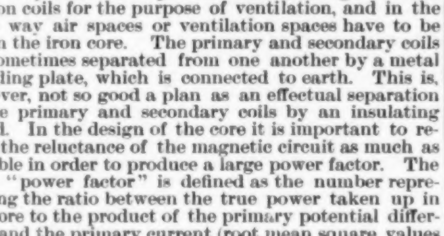


FIG. 30.

at no secondary load, is always an indication of large magnetic reluctance in the magnetic circuit, and hence open iron circuit transformers have always small power factors. The primary and secondary coils, having been placed upon the core and insulated from one another, the transformer is put into an iron case which is constructed to be watertight. Many manufacturers include in the same case porcelain plates or terminals, to which they attach the extremities of the primary and secondary coils. This, however, is not so good a plan as connecting by a highly insulated joint the extremities of the primary and secondary coils to highly insulated cables, which are brought out through watertight glands in the iron case, any necessary connections to fuses or switches being then made outside. In the design of large transformers, one important consideration is getting rid of the heat. A transformer ought never to rise above 100° Centigrade under any conditions of use, and for every watt which is lost in hysteresis, and by copper resistance, at least 3 to 4 square inches of cooling surfaces must be provided. In the case of very large substation transformers, it has even been found advantageous not only to leave ventilating spaces in the core but to force a draught of air through the transformer to keep it cool. In some cases a highly insulating oil is put into the case, but the insulation of the transformer must be good enough to work without it. The use of the oil is merely to keep out damp air, and even then it is not always successful in preventing breakdown. The notion that oil could be used as an insulation for transformers, which would heal up again after the passage of a spark or arc, was not confirmed by experience. As regards the general design of transformers, the battle of open versus closed iron circuit transformers was fought out and decided long ago. Open circuit transformers—such as the hedgehog transformer—have no advantage over the closed iron circuit transformer in respect of core loss per kilowatt output, and they have a decided disadvantage in a smaller power factor. Moreover, in a closed iron circuit trans-

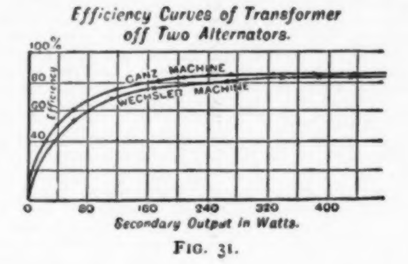


FIG. 31.

former, as the transformer is loaded up, the power factor very soon reaches unity; the curves in Fig. 30 show the manner in which the power factor of several different types of transformer varies as the transformer is loaded up. In a good closed iron circuit transformer, with small magnetic reluctance, a very little loading of the secondary circuit brings the power factor up to unity. In the case of a 6 kilowatt Mordey transformer I found that loading up to 1-60th of full load brings the power factor up to unity. The advantage of large power factor means that we have a small root mean square value in the magnetizing current at no load, and, therefore, a small heating loss in the main supplying the current of that transformer. When the transformer is at work we not only have energy losses going on in the iron, but, at the same time, we have energy losses in the copper called the copper losses, which are

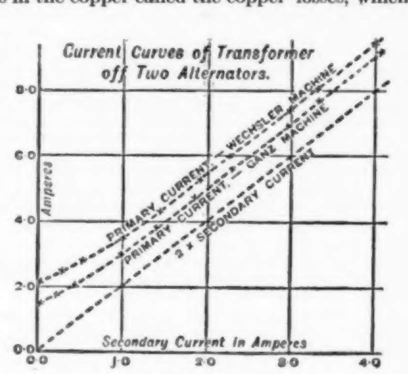


FIG. 32.

due to the resistance of the copper circuit. It can be shown the most advantageous ratio between the copper losses and the iron losses is to so construct the transformer that at full load the total copper losses are equal to the total iron losses. In very large transformers, where the secondary circuit consists of very thick copper bands or wire, if magnetic leakage exists to any sensible extent, we may have eddy current losses set up in the copper circuits, and this, in addition, may be a source of energy waste. The copper resistance operates not only to cause a large energy loss, but partly to account for what is called the secondary drop of the transformer. If a transformer is connected to a constant potential primary circuit, and if the secondary circuit is gradually loaded up, the potential difference between the secondary terminals is less when the transformer is fully loaded than it is when the transformer is on open secondary circuit. This difference is called the secondary drop. This drop is

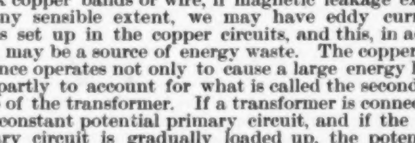


FIG. 33.

due to three causes: first, the resistance of the primary circuit; secondly, the resistance of the secondary circuit; and, thirdly, to magnetic leakage. As far as regards the copper resistance, we may calculate the secondary drop by the following formula:

$$\text{Secondary drop} = \frac{100 \times (C_1 - \text{mag.cur.})R_1}{E_1} + \frac{100c_2R_2}{E_2}$$

Where C_1 is the R. M. S. of the primary current.
C_2 is the same value for the secondary current.
R_1 is the resistance of the primary circuit.
R_2 is the resistance of the secondary circuit.
E_1 is the difference of potential between the primary terminals.
E_2 is the difference of potential between the secondary terminals

taken when the transformer is on open secondary circuit, and the symbol mag. cur. stands for the magnetizing current of the transformer, that is, the primary current when the transformer is on open secondary circuit.

This formula, however, only gives us that part of the drop which is due to the copper resistances; the actual observed drop would be greater than this by an amount due to magnetic leakage.

In dealing with the testing of transformers in our next lecture, we shall discuss the method by which this drop may be measured. In considering the action of transformers, it is important to notice that the iron core loss of the transformer, the secondary drop and the power factor of the transformer at no load are all greatly affected by the form of the curve of primary electromotive force. It is the custom sometimes to speak of the core loss of a transformer as if it were a quantity inherent in the transformer itself, and which could be exactly specified for any particular instrument. As a matter of fact, this is not the case. Experiments carried out with different transformers worked on different alternators, by Dr. Roessler in Germany and by myself in England, have abundantly demonstrated that the form of the curve of primary electromotive force has an immense influence on all the above-mentioned quantities. Dr. Roessler employed two machines, one a Wechsler and the other a Ganz alternator. When these machines were running on open circuit, the Wechsler alternator gives a curve of electromotive force which has a well rounded form; whereas the Ganz machine has a curve of electromotive force which has a very sharp or peaked form. The machines I chiefly employed in my own experiments were the Mordey alternator, the Thomson-Houston alternator and a Ferranti machine. The form of the curves of electromotive force of the first two named machines, under various conditions, have been shown in Lecture I. The general effect of all these experiments has been to demonstrate that when a transformer is worked off an alternator giving an electromotive force curve with a very sharp or peaked form, the effect of this is to make the iron core loss less, and the secondary drop greater than it is if the same transformer is worked off an alternator having a curve of electromotive force with a rounded or square shouldered form. If, therefore, we draw an efficiency curve for a transformer, that efficiency curve giving the efficiency—that is to say, the ratio between the watts delivered from the secondary to the watts taken in on the transformer circuit—and express this efficiency in terms of the fractions of the secondary load of the transformer, the form of that efficiency curve will be affected by the nature of the machine which is supplying the primary current. In Figs. 31, 32, 33 are shown curves illustrating the effect of the employment of different alternators on the same transformer in affecting the efficiency, primary current values and secondary drop of any given transformer, when taken on open secondary circuit.

For fuller information on this point, the reader is referred to the treatise on the "Alternate Current Transformer"* (vol. i, chap. vi, new ed.), by the present writer, which will supply more details on this question than we have space to consider here.

SCIENTIFIC EDUCATION IN GERMANY AND ENGLAND.†

IN our frequent discussions on scientific education we have both often been struck with some points of very great difference between the English and the German way of dealing with it. As it may be asserted without national arrogance that university education is in Germany in a more satisfactory condition than in your country, you are, of course, anxious to know which of the German customs I consider most effective in bringing about this better state of things; and I will, therefore, try to point them out. Of course, I shall confine myself to the subject of natural science, and especially chemistry and physics, feeling myself unable to deal with sciences beyond my knowledge. The main point of our system may be expressed in one word—freedom—freedom of teaching and freedom of learning. The first involves for the teacher the necessity of forming in his mind a clear conception of the scope of his science, for as he is free to choose any possible method of view, he feels himself answerable for the particular one he has chosen. And in the same way the student feels himself responsible for the method and the subjects of his studies, inasmuch as he is free to choose any teacher and any subject. One who has not seen this system in action may be inclined to think that such a system must lead to arbitrary and irresponsible methods on the side of the teacher, and to confusion on the part of the student. But the former is avoided, because at the beginning of his career the teacher is dependent for his advancement on the results of his scientific views, and is naturally anxious to improve his position in the educational world. And as for the students, they themselves impose certain restrictions on their own freedom. Most of them feel that they require some advice and guidance, and they therefore follow the usual and approved order in conducting their studies. As to the inventive man of original ideas, it has often been proved that for him any way is almost as good as any other, for he is sure to do his best anywhere. Moreover, such a man very soon excites the interest of one of his teachers, and is personally led by him, generally to the great advantage of both.

Let me illustrate these general remarks by considering the course followed by an average chemist. In his first half year he hears lectures on inorganic chemistry, physics, mineralogy, sometimes botany, and of late often differential calculus. Moreover, the German student is accustomed to take a more or less strong interest in general philosophy or history, and to add in his Belegbuch (list of lectures) to the above named Fachcollegien (specialized studies) one or two lectures on philosophy, general or German history, or the like. Very often there are in the university one or more popular professors whose lectures are heard by students of all faculties without reference to their special studies. The student who has heard during his stay at the university only lectures belonging strictly to his Fach is not well thought of, and is to some extent looked down on

* "The Alternate Current Transformer in Theory and Practice." 2 vols. The Electrician Printing and Publishing Company, 1 Salisbury Court, Fleet Street.

† A letter from Prof. W. Ostwald, communicated by Prof. W. Ramsay to the London Times, August 25.

as a narrow specialist. But I must add that such views are not prevalent in all faculties, and there are some—e. g., the faculty of law—whose students confine themselves, with few exceptions, to attending exclusively lectures in that faculty.

In the second half year the chemical student begins with practical laboratory work. Notwithstanding the perfect freedom of the teachers, the system first introduced by Liebig into his laboratory at Giessen is still universally adopted in German universities and technical high schools, viz., qualitative and quantitative chemical analysis, the former conjoined with simple spectroscopic work, the latter amplified by volumetric analysis. This is followed by a course of chemical preparations, formerly chiefly inorganic, now chiefly organic. Even here a regular system is being widely developed owing to the use of some well-known text books. Of late years this course is followed in some laboratories by a series of exercises in physical chemistry and electro-chemistry.

While these practical exercises, which last three or four half years, are being carried out, the student completes his knowledge of physics, mathematics, and the other allied sciences by hearing lectures and working practically in the physical and often also in some other laboratory. The exercises done, he goes to the professor and asks him for a "theme" to begin his "work," viz., his dissertation for the degree of doctor of philosophy. This is the most important moment in his life as a student, for it generally determines the special line of his future career. The "theme" is usually taken from the particular branch of the subject at which the professor himself is working; but, as the scientific name and position of the professor depends not only on his own work, but to a large extent on the work issuing from his laboratory, he is careful not to limit himself to too narrow a range of his science.

Of course it is best of all if the student selects for himself a suitable "theme," suggested to him by his lectures or practical work, or from private study of the literature of the science. But this seldom happens, for the young student is not yet able to discern the bearing of special questions, and lacks knowledge how to work them out. Sometimes (but not very often, indeed) he points out to his professor in a general way the kind of problems he would like to work at, and the professor suggests to him a special problem out of this range of subjects. During the working out of his chosen subject the student learns generally much more than he has heard at lectures. Every part of the investigation forces him to revise the scientific foundations of the operations he performs. During this time the incidental short lectures given by the professor on his daily round from one to another of the advanced students are most effective in deepening and strengthening the student's knowledge. As these explanatory remarks are generally heard not only by the student whose work has caused them, but also by a number of fellow students working near, a fairly wide range of scientific questions are dealt with in their hearing. Often these small lectures develop themselves into discussions, and, as for myself, I judge from the frequency of such discussions between the students whether the session will turn out a good one or not. If the professor thinks the work sufficiently complete to be used as a dissertation, the student proceeds to the close of his studies. He prepares himself for the examination, which is conducted by the very professors whose lectures he has heard and in whose laboratories he has worked. This examination varies somewhat in different universities, but in no case is it either very long or extensive; indeed, it is not considered as very important. For we are all aware what an uncertain means of determining a man's knowledge and capabilities an examination is, and how much its issue depends upon accidental circumstances. Part of this uncertainty is removed by the fact that the professor and the pupil know each other, are acquainted with one another's modes of expression and scientific views. The main purpose of the examination is to induce the student to widen his knowledge to a greater extent than is covered by the subject of his dissertation; but, indeed, it happens very seldom that a student whose work is considered sufficient does not pass the examination.

We have no great fear that this system may induce a professor to treat his own pupils in too lenient a way, and so lower the standard of the doctor's degree. There was a time when such abuses used to occur, but there very soon arose such public indignation that the abuses ceased to occur. Even at the present day similar instances occasionally occur, but, as before remarked, the position of a professor depends in such a degree upon the value of the dissertations worked out under his supervision that such deviations from the right way correct themselves in the course of time. The most effective instrument for that purpose is the publication of all dissertations and the consequent public control over them; for this reason publication is, I believe, compulsorily prescribed in all German universities.

When the student has finished his course he is still entirely free to choose between a scientific and a technical career. This is a very important point in our educational system; it is made possible by the circumstance that the occupation of a technical chemist in works is very often almost as scientific in its character as in a university laboratory. This is connected with a remarkable feature in the development of technical chemistry in Germany—the very point upon which the important position of chemical manufacture in this country depends. The organization of the power of invention in manufactures and on a large scale is, as far as I know, unique in the world's history, and it is the very marrow of our splendid development. Each large work has the greater part of its scientific staff—and there are often more than 100 doctores phil. in a single manufactory—occupied, not in the management of the manufacture, but in making inventions. The research laboratory in such a work is only different from one in a university by its being more splendidly and sumptuously fitted than the latter. I have heard from the business managers of such works that they have not unfrequently men who have worked for four years without practical success; but if they know them to possess ability they keep them notwithstanding, and in most cases with ultimate success sufficient to pay the expenses of the former resultless years.

It seems to me a point of the greatest importance that the conviction of the practical usefulness of a theoretical or purely scientific training is fully understood in Germany by the leaders of great manufactories. When, some years ago, I had occasion to preside at a meeting, consisting of about two-thirds practical men and one-third teachers, I was much surprised to observe the unhesitating belief of the former in the usefulness of entirely theoretical investigations. And I know a case where, quite recently, an "extraordinary" professor of a university has been offered a very large salary to induce him to enter a works, only for the purpose of undertaking researches regarding the practical use of some scientific methods which he had been working at with considerable success. No special instructions are given to him, for it is taken for granted that he himself will find the most promising methods; only, in order to increase his interest in the business, part of his remuneration has been made proportional to the commercial success of his future inventions. From this clear understanding of the commercial importance of science by the directors of the industrial establishments there science itself gains another advantage. A scientific man can be almost sure, if he wants in his investigations the help of such technical means as only great works can afford, that he will get such assistance at once on application to any work; and the scientific papers of German chemists very often contain acknowledgments, with due thanks, of considerable help they have thus obtained.

Besides these advantages for the development of scientific and technical chemistry in Germany there exists another very important factor—practical assistance from the government. Universities are in Germany affairs of the state, not of the empire, and in no other point has the division of the Fatherland into many smaller countries proved itself to such a degree a boon and a blessing. The essential character of the German universities, the freedom conferred by the independence of the numerous universities, is never lost. There have been hard times occasionally for the universities of one country or another; but some universities were always to be found where even in times of hard oppression liberty of teaching and learning remained complete and unaffected, and the spirit of pure, unalloyed scientific research was preserved and encouraged. So this palladium of intellectual freedom has never been lost; and it regained the former influence as soon as the casual oppression ceased. In our days there is among all the separate state governments in Germany a clear conviction of the importance of practical support being given to pure scientific research. To take one instance, in order to facilitate teaching and research in electro-chemistry (a recently developed branch of science), a suggestion by some leading practical scientific men to the members of the government was sufficient. Upon such a suggestion a considerable sum of money was spent first by the Prussian government for the endowment of electro-chemical chairs and laboratories in the three "polytechnic" colleges of that country. A short time afterward it was resolved to erect at one of the universities (Göttingen) an institute for physical chemistry, and especially electro-chemistry, in the shape of a building which has just been completed. At the same time, other German countries have begun to grant to their universities and technical colleges considerable sums of money for similar purposes, e. g., the Saxon Landtag alone has unanimously voted half a million marks (= £25,000) for the erection of a splendid laboratory for physical chemistry at Leipzig.

You will excuse my boasting about our German management of this most important question of scientific education. It is no blind admiration without criticism, for I know by practical experience the management in other countries, and I can compare them. And it is only for the sake of science itself that I write these lines. If they should help the spread of the conviction of the incomparable practical usefulness of every support given to pure science, together with the recognition of the fact that the latter can only grow in an atmosphere of liberty and confidence, I should regard it as tending toward the progress of science itself, and destined to exercise such an influence on scientific progress as may be compared with the discovery of the most remarkable scientific fact.

SOME COMMON DISEASES OBSERVED NORTH OF THE ARCTIC CIRCLE.*

By JOHN E. WALSH, M.D., Washington, D. C., Surgeon to Peary's Relief Expedition, 1895.

I THOUGHT it might be interesting, as showing the geographical distribution of certain diseases observed during my summer trip among the northern races of man. Since consulting my diary and memory, I find that I have less on this subject than I thought, and therefore my paper is medical only to a slight degree. Instead of the title given it might more properly be called "The Eskimos, their country, habits, customs and diseases." I apologize, and hope you will pardon me for not giving you something more consistent with the objects of our Society.

The expedition of which I had the honor as well as pleasure of being a member, and having for its object the relief of Lieut. R. E. Peary and the collection of material for the American Museum of Natural History, sailed from St. Johns, N. F., July 11, 1895, on the steam sealer Kite. Our party consisted of twenty-one persons in all, passengers, officers, and crew. None of the party during the trip suffered any very grave illness. Rheumatism, urticaria, hemorrhoids, cold, and constipation were the only ailments.

Constipation, I am told, is the most troublesome complaint that affects Europeans in the northern waters. This is due, I think, to a lack of exercise, a disinclination to go to stool on account of the cold, and to the fact that little water is drank.

After an uneventful foggy voyage, we arrived at Holsteinberg, latitude 67° N., July 19, and left on the 20th for Godhaven, reaching there the next day. After a short stop at this place, we sailed eastward to Jacobshaven, and afterward up the Weigat or strait separating Disco Island from the mainland, stopping for fossils at a place called Atanekerdluk, 70° N. This was our last stopping place in South Greenland.

After crossing Melville Bay we came to the country of the Arctic Highlanders, or North Greenland.

We attempted to enter Bowdoin Bay, at the head of which was Peary's headquarters, but were stopped by the ice in Inglefield Gulf. After a delay of a day or two we put into McCormick Bay, took Lieut. Peary on board, hunted walrus, duck, and deer about the gulf, and then sailed north as far as Cape Sabine, latitude 78° 40′ N., where Lieut. Greely was picked up several years ago. After a short stay in Inglefield Gulf, we sailed south to Cape York, near that place getting the meteorites on board, and then crossed Baffin's Bay to the west coast, going twenty-seven miles up Jones' Sound, which separates Elsmenland from North Devon. Then taking our course southward, put into Dexterity Harbor, where we had an opportunity of seeing the west coast natives, who, although of the same race, are different from the Greenlanders.

Leaving this place, and after having been held in the ice pack for several days, we arrived at Godhaven again on the 11th of September. After stopping here about twenty-four hours our anchor was weighed and course set for St. Johns, where we arrived, after a stormy passage, September 21st. This, in brief, is our itinerancy.

Greenland, as you are aware, is divided into two divisions, the central part, which is occupied by the great ice cap, and a strip of from five to twenty miles wide between it and the coast. This strip consists of rough and rugged mountain peaks and ridges having between them valleys, down which glaciers, solid rivers of ice, make their way slowly but irresistibly to the sea, there to break off and form icebergs, the terror of trans-Atlantic travelers.

As may readily be supposed, this strip is the only inhabitable portion of the country, the Danes having settlements from Cape Farewell as far north as Upernavik, 73° N. The settlements are mostly near the entrances to the fjords, and those I have seen have most perfect land-locked harbors. The soil is very scanty in quantity, but what there is, I think, is rich in quality, and had they a longer summer is capable of producing vegetation.

In spite of the cold and long winters they have some little vegetation in the way of mosses, grass and flowers. There are quite a variety of flowers, the most common being the Arctic poppy, which grows in great abundance and in all places. As far north as we went, 78°45′, this flower was seen, and just on the edge of the ice cap, where there was a strip of moraine about twenty feet wide, with the snow hill descending to the plain on the other side, these flowers were blooming in great profusion.

There are no trees except the ground willow and birch, which grows about six inches high and runs along for three or four feet.

For six months in the year at Godhaven, and for four months in North Greenland, total darkness reigns.

The temperature varies in the winter from thirty to sixty degrees below zero, and in the summer averages about 38°. The intensity of the cold is not felt so much as it is in this latitude. Dr. Hall, speaking of this, said: "On December 8th, at noon, the thermometer was at zero, and on the 9th 15° below zero, or 47° below the freezing point, yet strangely to me the cold was not felt so much as I should have supposed." Referring to the same thing, Dr. Benjamin Vreeland, U. S. N., on the Advance, in the winter of 1850-51, says: "We sat on deck viewing and applauding representations in which female characters appeared on the stage with bare necks and arms, when the thermometer was 46° below zero."

Of course we did not experience any such temperature as that, but with the mercury at 34° Fahr. I have slept on the moss among the rocks, within 300 feet of a glacier, with no covering other than my ordinary clothing, consisting of medium weight flannel underwear, flannel shirts, pants, and light weight sweater, and suffered no inconvenience from it. I could not do that here with the temperature at 60°. The rainfall is very slight, there being only two weeks in the year in North Greenland when it rains at all. Fogs are very prevalent during the summer.

The people with whom we came in contact were of three different classes. The Greenlanders, who inhabit Danish Greenland, and whom we saw at Holsteinberg, Godhaven, and Jacobshaven, are not pure Eskimo; in fact, I do not believe there are any pure Eskimos in South Greenland. They are about three-fourths Danish blood, and to a great extent possess the Danish cast of features, with all the Eskimo dirt and squalor.

The men are slightly below the average height, though some are tall, and are generally dark, though there are some light ones among them. They are undemonstrative, phlegmatic, to a certain degree, but are cheerful and seldom quarrel.

The women are slightly smaller, better looking, and do the hardest part of the work. These people are intelligent, and to a certain degree educated. A strange thing is that they cannot or will not learn Danish. They pick up a little English from the few ships that come there, but although they have a Danish governor, minister and teacher, they cannot master one word of their language. Their clothing, consisting of pants, shirts, and kanicks, or boots, are made from the skin of the seal.

Their habitation is made of stone walls raised to a height of about five feet, with a peaked roof rising about five feet higher. The spaces between the rocks are filled in with sod and turf, and when covered with ice in the winter are quite warm. Most of them are lined with wood. The entrance is through a long, narrow passage, about four feet high, which serves the double purpose of keeping out the cold winds and as a shelter for the dogs.

Their surroundings are most unsanitary. All about the entrances and sides of the house is soggy, wet ground, covered with urine, excretæ—both human and dog—bones, and everything for which they have no use. The people are dirty in their habits, washing but seldom, and sleeping all together, men, women, and children, in one bed, which is only a wooden platform covered with bags of moss.

Their food consists of the flesh of the seal, fish, deer, and vegetables and cereals obtained from Denmark. They are great users of tobacco, both for smoking and chewing, and are fond of wines.

Their chief occupation is hunting the seal, reindeer, and fishing.

The second class is the Arctic Highlanders, number-

* Read before the Medical and Surgical Society of the District of Columbia, December 9, 1895.—Virginia Medical Monthly.

ing 250, who inhabit the coast north of Cape York, between 75° and 79° north latitude. They are pure Eskimo, and are a laughing, good natured people, intelligent, and quick to see into things.

They are short of stature, stout, and well nourished, with dark broad faces, broad nose, good mouth and teeth, dark eyes, some set obliquely, heavy eyebrows, and long abundant black hair, but not much on the face. Legs short, body long, arms about normal, feet and hands small.

These people are even more undemonstrative than those of South Greenland. Nothing seems to surprise them. Even the houses, horses, steam cars, etc., of our country failed to elicit one exclamation from the Eskimo girl whom Mrs. Peary brought home with her.

They are totally devoid of education, except as to what appertains to their own mode of living and hunting. They are very filthy about their persons and habitations. I don't believe they bathe or wash themselves. Their costume consists of seal, deer, and bear skins, even more dirty and ugly than that of the native of Danish Greenland. When they stoop or bend over, a space of three or four inches is made between their shirt and pants, through which a portion of their body is seen black and grimy with dirt.

In the summer they live in tupiks or tents, about five or six feet in diameter, made of seal skins, with the hair scraped off. The interior and exterior are filthy in the extreme—excretæ (dog and human), urine, and refuse of all kinds being all about them.

One half the tupik is taken up by a pile of skins, upon which the whole family, and sometimes visitors, sleep—men, women and children, all crowded together and perfectly nude. Everything about them is oily.

In the winter they occupy ingloos or huts built of stones, arranged circularly, half underground, with convex roof, having a hole in the top for ventilation and exit of smoke. The entrance is through a long corridor several feet in length, through which they crawl on hands and knees. These are much dirtier than the tupiks, and when filled with natives, their dogs, skins, kamiks drying over the lamp, and smoke from burning blubber filling the place, one cannot imagine how they live at all, and wonder why they have no more diseases than they have.

Their food consists of flesh entirely, using that of the walrus, seal, narwhal, white whale, reindeer, duck, little ant, and sometimes dog. They do not use salt at all, and have no vegetables whatever.

They have no religion, so far as I could discover, but believe that a bad spirit gets into things sometimes. Neither have they any system of medicine, although they have an angopop, who corresponds to the "medicine man" of the Indians, and who pretends to have the power of driving away the evil spirit.

They have no ceremonies of any kind. When a man desires to marry he takes a girl on trial for awhile, and if she does not suit, returns her. They also trade their wives for a time.

The third class of Eskimos referred to were seen on the west coast of Baffin's Bay, at Dexterity Harbor, about latitude 72° N.

Although of the same race as the Arctic Highlander, they are much inferior mentally. Their mode of life is the same, except, I believe, in the winter they live in ice ingloos.

The females of this tribe have their faces, wrists and hands tattooed in a fantastic manner. I think the number of marks has something to do with their married life. What it was I was unable to ascertain.

Dr. Hall says the tattooing is the mark of married women, though unmarried ones sometimes tattoo. He says it is done from principle, the theory being that the lines thus made will be regarded in the next world as a sign of goodness.

From this we may conclude these natives had an idea of a future state, although their cousins across the bay had not. I do not think his theory is a good one, for if that was the object of the tattooing, the men would do it also, whereas they do not mark themselves.

The tattooing is done by means of a piece of sinew, blackened with soot, and then drawn under and through the skin by means of a needle.

The dead of the Eskimos are not buried, but placed in mounds of rocks, and are thus exposed to the wind and weather. The Eskimos suffer very little from disease, and the mortality is not high among them. From September, 1894, to September, 1895, there were only three deaths and seven births, and during the preceding year seven deaths and five births.

Of the deaths, one was from "a great blood" and one from "cough." The rest were the result of accident either to their kyaks, on the ice, or falling from cliffs. As might be expected, catarrhal affections, due to the cold, and rheumatism are prevalent, especially during the winter season.

At Karnah, a village near Peary's headquarters, most of the natives were suffering from coryza, a bloody mucous discharge issuing from their nose and all coughing considerably. In South Greenland also, many were troubled the same way. I was not surprised to find tuberculosis common in Danish Greenland, but was very much amazed to find not only this disease, but also la grippe and gonorrhœa among the Arctic Highlanders. Of course, tuberculosis and gonorrhœa can be traced to the advent of Europeans, but it is rather hard to account for the grip, as so far as I could learn, none of Peary's party had the disease when they arrived, and except for a whaler once in a great while getting as far north as Cape York, they have no other communication with civilization.

Of course after such germ diseases are introduced, it is quite natural for them to be conveyed throughout the tribe. Their habits of taking a wife on trial, trading wives, and crowding together in close, unsanitary dwellings, favor the spread of such diseases.

From one of the whalers gonorrhœa was introduced, and went through the whole tribe. It ran a mild course, however, and they soon recovered.

Dr. Hall, in speaking of the west coast natives, says: "I was very sorry to find several of my Junnit friends at this place (Cape True) very sick from the complaint that was introduced to their race when first brought into contact with civilization, viz., consumption." Mentioning one of them, he says: "Sharkey's wife was rapidly declining; her bleeding at the lungs had left her white as the driven snow and poor as fleshless bones could be."

He noted several cases of this disease. Among the South Greenlanders, I observed two men suffering from pulmonary tuberculosis, and a girl suffering from tubercular knee joint; and in North Greenland a man, woman and boy, with pulmonary tuberculosis, and a girl with hip joint disease, probably tubercular. The disease in these persons seemed to run about the same course as in people here.

In regard to la grippe, Drs. Vincent and Cook, who each spent a winter with Peary, said the natives suffered with that disease, and in South Greenland the physician said the same thing. Although I did not see any cases of it, I treated several persons for prostration that often follows this disease.

Other affections for which I treated patients were several cases of rheumatism and two of neuralgia, in South Greenland. Among the Arctic Highlanders was a young man suffering from chronic rheumatism, who was unable to walk. He had been confined to his bed of skins for a year and was very much emaciated.

There was also a man who had an attack of cellulitis of the hand, following an injury from a harpoon. It was nearly well when I saw it, except that his fingers were stiff, and for that reason he was unable to close his hand.

Among the west coast natives at Dexterity Harbor, was observed one case of meningitis, probably tuberculosis, in a boy about six years old, and also a case of abscess of breast. The boy, when seen, was lying on his back on a pile of skins. He was taken sick about three or four days before, and his condition had not changed when I saw him. His temperature was not elevated, nor was his pulse disturbed very much. His tongue was coated heavily; he had no appetite, and was constipated. His appearance was characteristic of meningitis. He lay with his eyes closed, and when aroused would get impatient, wrinkle up his face, etc., but when undisturbed would lie perfectly quiet, with a placid look on his face. When the finger was drawn across the forehead, the characteristic red line was produced. Our short stay prevented me from observing him more carefully.

I saw the woman with the abscess of the breast one day, and again about thirty-six hours after. When first seen it was quite large, red, and inflamed, with pus oozing from a very small opening. She had it hanging outside her coat, exposed to the cool air. I wanted to open it, but she declined. When next seen the swelling had gone down entirely; very little redness remained; no pus was present, and she said it was all right.

I had expected to find scurvy among them, but did not see a case. I am of the opinion that they do not suffer from it. This is a disease that Europeans who have wintered in the north have been affected with from time to time.

Among the officers and crew of the Advance and Rescue, who wintered north in 1850–51, out of eight officers and twenty-seven men, one officer and nineteen men had the disease.

Fortunately, our party not having any of the conditions favorable to it, escaped this disease.

I examined many of the natives for evidences of syphilis, but found none, nor did those who had spent two years with them, and were acquainted with every individual, know of a single case. I believe them to be entirely free from it.

JOINTING OF SEWER AND DRAIN PIPES.*

By R. S. ROUNTHWAITE.

THERE have in past years, the author believes, been several papers upon this subject read before meetings of this association, but these have not dealt at any length with the specific points which it is now proposed to submit for your consideration.

The papers to which allusion has been made deal rather with the many patented pipes and pipe joints than with the question of a jointing medium, and the author of this paper, therefore, has been led to introduce the subject of jointing sewer and drain pipes with the hope of raising a useful discussion upon the relative merits of Portland cement and clay for this purpose.

By many members of this association, and by many who are outside it, the author is aware that clay jointing is looked upon as a relic of paganism and ignorance; nevertheless, he is, with present improvements and experience, in favor of it as opposed to cement, and will to-day endeavor to state his views with regard to the two classes of joint as impartially as possible. But before proceeding it will, perhaps, be well to inform this meeting why such a subject as this should have been selected.

In the first place, puddled clay joints have been used and relied on in the borough of Sunderland and district without question for the last forty years. Recently, however, at inquiries held by the Local Government Board into applications made by the health authorities of a neighboring borough and of an adjoining urban sanitary district, the board's inspectors and the board have informed the authorities in question that sanction would only be granted on condition that the joints were made in cement.

Considering the very great difference of opinion which exists upon this subject between gentlemen who are daily engaged in carrying out works of sewerage, and who are therefore eminently capable of judging as to what is best under varying conditions, the author ventures to think that the time has not yet arrived when a central authority can with advantage to the community lay down any fixed hard and fast rule in this matter; and he is, moreover, strongly of opinion that the professional adviser of a sanitary authority (provided he has any lengthened experience in the sub-strata of his district) should be better able to judge as to the more suitable material to use than one who may make an occasional visit to the locality, and who cannot therefore possibly know anything of the nature of the subsoil or of the quality of the clay which can be obtained, for after all, much, if not everything, depends on this. This question has also again frequently cropped up since the establishment of the Sanitary Inspectors' Associations. They insist, as a rule, upon having drains laid with cemented joints, and this work is done with occasional supervision only, and by workmen who have not had any special training or experience. The author has, therefore, been unable to report work so done as satisfactory in his judgment, and indeed in several instances after the lapse of a very few years has found work done in this manner to have been defective from end to end.

With the view of ascertaining as far as possible the practice and experience of the engineers and surveyors to other corporations and sanitary authorities, the author addressed a number of queries to these gentlemen on the subject, and he will further on briefly allude to the replies received by him with reference thereto.

The objections urged against the cement joint are, in the author's opinion, by no means few or insignificant, and may, perhaps, be best considered in the following order, viz.: (1) There cannot be sufficient certainty that in the execution of the work the joint is carefully and properly wiped off in the inside, and that no ridge of cement will be left inside to harden at the joint. The least carelessness at this point will undoubtedly cause an accretion of sediment, which will grow and grow until it attains such proportions as must result in serious deposits, and the consequent generation of noxious sewer gases. (2) Neither can there be any certainty that after the pipes are jointed and while they remain uncovered, workmen will not walk or step upon them. With every care and supervision this will occur, and to a cement joint especially must be and is disastrous. (3) After the joints are made and set, or partially set, the author is not by any means satisfied that the weight of earth filling, together with the process of filling and ramming, does not cause some degree of subsidence or sufficient and unequal settlement to fracture the joint. (4) In case of such fracture leakage is almost certain to take place, and must eventually result in subsidence of the adjoining pipes. (5) In making branch connections with a sewer or drain jointed in cement, and in case of a stoppage in pipes similarly jointed, it becomes necessary to break away and remove several pipes before being able to secure a perfect socket for making good, and, further, in making good such pipes with cement it is not possible to wipe off inside the cement joint, so that a ridge is necessarily left. (6) It is also a point worthy of some consideration whether or not the unglazed socket and faucet do not absorb the moisture from the cement to such an extent, and so rapidly, as to prevent the possibility of obtaining a perfectly reliable joint throughout. Then again, there is a great risk of getting cement which has not been well matured and cooled.

In the author's judgment it is requisite that the jointing medium used should permit of some slight yielding in order that fracture and consequent leakage may be prevented. It is all very well to stipulate that the earth shall be hollowed out to the exact shape of the under half of the body of the pipe and of its socket, but we all know that in practice this is not done, and therefore there must be settlement in a greater or lesser degree.

The author has appended hereto a short abstract showing those towns where clay is used and those towns where cement is used, together with a column of remarks based upon the replies received. It is particularly worthy of note that in every instance a clay band or collar is laid over the cement joint, and this appears to the author to indicate a want of faith in the cement joint alone. With many of the engineers it is laid down as a sine qua non that this class of work must be done by a specially trained staff employed by the corporation. The author quite indorses this view, whether the joints be of one material or the other, but if this idea were generally adopted we should have to say good-by to our drainage contractors.

But apart from this, how is it possible to compel land and house owners to intrust their work to the corporations? The acts of Parliament having reference to the subject require that such owners themselves shall do it; and how would it be done? Personally, the author does not think it practically possible to get men to make perfect cement joints.

Replies have been received from the engineers and surveyors of eighty-five of the principal cities and boroughs in the United Kingdom to queries addressed to these gentlemen upon this subject. These replies have been shortly tabulated, and a general statement as to the practice adopted with some expressions of opinion thereon may perhaps be interesting to this meeting.

With reference to the second query, it appears that while in forty-three instances cement alone is used for jointing, eight towns use cement with a clay band over, twelve use both cement and clay, and twenty use clay alone. In two cases cement is used for sewers, while clay is the material adopted for drains; in one case only the reverse is the practice; and in one instance a clay joint is used with cement over. Tar and pitch are used in bad ground in one city; Stanford's composition in another; Hassall's joints are in use in five cases; Doulton's in one case, and Stanford's in one case. Here we have a considerable diversity of opinion (making every allowance for varying conditions), and the author suggests that while the engineers of such cities and boroughs as Middlesbrough, Birmingham, Bolton, Belfast, Blackburn, Bradford, Leicester, Rochdale, Cork, Derby, Wigan, Gateshead, Gloucester, Newcastle-on-Tyne, West Hartlepool, Hull, Sheffield, South Shields, Stockport, Oldham, and many others, adhere to the practice and believe in the use of clay in preference to cement, there is much room for doubt as to the superiority of the latter. From the replies received from those gentlemen who use cement there is much doubt expressed as to its efficiency, and indeed in one case the surveyor openly avows that he prefers clay; in two other cases that cement is not satisfactory; while replies such as the following—"always a risk of failure"; "except in quicksand or wet ground"; "except in cases of subsidence"; "fairly satisfactory"; "only with proper care and supervision"; "rigid and liable to crack in case of subsidence"; "so long as pipes are undisturbed"; "in dry ground"; "not perfectly"; "fairly so"; "when carefully executed"; "if properly done"; "generally"; "little if any better than a good clay joint"; "much depends on ground and workmanship"; "difficult to get men to use sufficient care"; "considerable risk of failure"; "great supervision required"; "should not like to say it is satisfactory"; "does not answer in ground liable to settle"; "liable to crack through vibration, settle-

* A paper read at the Congress of the Sanitary Institute, Newcastle-on Tyne, September, 1896, and published in Industries and Iron.

ment, rigidity, etc."; "cement joint with ordinary pipe not at all satisfactory"; "have found many cases of defective joints when done by ordinary drainer"; "lack of pliability for settling"; and many others in similar strain from gentlemen constantly using cement are not calculated to beget much confidence in this medium.

With reference to the last query, out of seventy-five replies, forty-three gentlemen approve of the method of jointing suggested, and which is adopted in Sunderland, while twenty-three only disapprove of it; nine others express opinions which may be fairly regarded as more or less favorable. A fair sample of these latter opinions is as under-quoted: "Good joint may be made with clay, but prefer cement"; "not so good as cement"; "possible to get good work in this manner, but prefer cement"; "it might be fairly satisfactory, but better to be on safe side and use cement"; "might be suitable in hard clay, but not as satisfactory as cement and gaskin"; "matter of opinion and fact" (!); "might be for some time, but should not regard it as a first class job."

The author is in a position to refer to practical foremen in Sunderland and other towns, some of them with forty years' experience in both classes of joints, who are most strongly in favor of clay as opposed to cement. In Wolverhampton and Portsmouth it is stated that there are many clay jointed sewers which after twenty years are found to be as good as when first laid.

The objections urged against the clay joint are: (1) Rats sometimes scrape away the clay, (2) worms bore through it, (3) roots of trees grow into the joints and fill the pipes, (4) joints do not remain watertight, (5) clay cracks in dry positions, (6) joints are forced when under pressure.

As to objection No. 1 it may be, but I never found it so; as to No. 2, worms will no doubt sometimes, though very occasionally, be found in a clay band; as to No. 3, no one would think of using clay where the roots were likely to be; as to No. 4, the assertion that the joints do not remain watertight is not correct; as to No. 5, that clay cracks when laid in dry positions may well be, but when is a cutting clay or ordinary earth 5 feet or 6 feet deep found to be wanting in moisture! As to No. 6, that the joints are forced under pressure, does this not depend on how the joints are made and stemmed? If a properly made clay joint will, without any support from the adjoining or superincumbent earth, stand a head equal to 6 feet of water (about which there is no doubt), and the trench is properly packed, filled in, rammed, and consolidated, the author does not quite see how even an extra 3 feet or 4 feet of head is likely to overcome the resistance of the earth.

The author's contention is for some jointing material which is sufficiently pliable and elastic to yield slightly in case of subsidence which may have been caused in any of the ways before mentioned. With a rigid joint, such as cement, something must give in case of settlement, either the joint or the pipe. In this relation a short quotation from the remarks made by Mr. G. F. Deacon, M.I.C.E., in his address to the engineering and architectural section of the Liverpool Congress, 1894, may not be out of place. He said: "I may be permitted . . . . to point out that except in very shallow cutting and suitable ground, you cannot, speaking generally, without greatly increased cost make stoneware pipes with rigid joints permanently watertight. Even cast iron pipes are commonly broken by irregular external pressure in deep trenches under the conditions to which stoneware pipes are sometimes subjected. As an example, stoneware pipes of 15 inches internal diameter of good manufacture, jointed with Portland cement, and supported in bearings 8 feet 6 inches apart, will only deflect before fracture $\frac{1}{30}$ inch. In most trenches more than a few feet in depth the unbalanced pressure (caused by irregular settlement of the filled in materials, which with the greatest care cannot be avoided) largely exceeds what is necessary to produce a flexure of $\frac{1}{30}$ inch in 8 feet 6 inches of cement jointed stoneware pipes. Thus we find that in a large proportion of such work that the pipes are frequently fractured. We also find that with the closest inspection it is most difficult to secure watertightness in ordinary cement made joints."

THE INFLUENCE OF LIGHT UPON THE PERIODICAL DEPTH MIGRATIONS OF PELAGIC ANIMALS.*

By Jacques Loeb, M.D.

As is now well known, the animal life in the ocean and of fresh water lakes is confined chiefly to two regions, one extending from the surface of the sea to a depth of about 400 meters, the other being the ground region of the ocean. We know, moreover, that a good many of the surface animals migrate periodically in a vertical direction, coming up to the surface during the night and going downward during the daytime, but not deeper than 400 meters. For the physiologist the question arises, What determines this peculiar vertical distribution and periodical migration of marine animals? My investigation concerning the effects of light on the motion and orientation of animals made it certain that this periodical depth migration of sea animals is determined, to a certain extent at least, by the light. In order to make this clear, I must give a short sketch of the way in which the light determines the orientation and motion of animals.

You all know that many animals, like the moth, for instance, go toward the light. It was believed that this was due to an attraction of the animals by the light, or at any rate that these animals liked the light. Other animals show the opposite reaction—they go away from the light. It was generally believed that these animals were fond of the dark. My experiments, however, showed that these reactions are the outcome of a purely mechanical effect of the light upon the animal, and that the animal, as a rule, is neither fond of the light nor of the dark. The light forces the animal to orientate itself in such a way that its symmetry axis or symmetry plane falls into the direction of the rays of light, and consequently all symmetrical elements of the surface of the animal are met by the rays of light at the same angle. There remain two possibilities—the animal in this orientation can turn either its oral pole or its aboral pole toward the light. In the former case I have called it positively and in the latter case negatively heliotropic. In the case of animals that are fixed to the ground, like hydroids, for instance, the only effect of the light consists in this orientation of the animals. But in the case of animals that are free moving, like insects or copepods, the animal is orientated by the light, and is forced to move in this orientation. The consequence is that if the animal is positively helitropic it must necessarily move straight toward the light. If the animal is negatively heliotropic, it must move straight in the opposite direction. That the motion of the animal is determined by the direction of the rays of light, and not by the differences in the intensity of the light, can be very easily shown. Positively heliotropic animals, like plant lice, move toward the source of light, even then, if by certain experimental arrangements their path goes from lighter to darker places; and negatively heliotropic animals go from the light, even then, if measures are taken so that their way leads them from the dark to the light. But in both cases the animal migrates in the direction of the rays of the light. An illustration will show this influence of the direction of the rays of light better than a long theoretical explanation.

Spirographus spallanzani, a marine annelid, lives in a tube which it fastens to the ground. The tube is not transparent, and only the tentacles of the animal, which project from the tube, are exposed to the light. The tentacles are arranged in a circle. If we put these animals into an aquarium in which the light falls from only one side, the animal bends its tube in such a way that the symmetry axis of the circle of tentacles is parallel to the rays of light. As long as we do not change anything in the direction of the rays of light which strike the animal, it does not change its orientation, but as soon as we cause the light to fall into the aquarium from another direction the Spirographus changes the direction of its tube so that the symmetry axis of its tentacles is again parallel to the rays of light. Whether the intensity of the light is great or small, whether we use direct sunlight or diffused daylight, the result remains the same.

The larvæ of Limulus at a certain period of their life are negatively heliotropic. If we put such larvæ into a glass dish and place it near a window through which the rays of the sunlight fall obliquely, the limuli migrate with mathematical exactness in the direction of the sunlight away from the window as far as the sides of the dish allow them to go, and then they remain at rest. If, however, we turn the dish 180 degrees around its vertical axis, the animals move again in the direction of the rays of the light, going away from the window. It is not possible to give you here a full account of the experiments by which it can be proved that the direction of the rays of the light alone determine the direction of the motions of the animals, nor is it possible for me to give you here the theory of animal heliotropism. For both I must refer you to my former publications. I only wish to show how this heliotropism determines the periodical depth migrations of pelagic animals. It is known that the nauplii of Balanus appear at the surface of the sea at night and go down during the day time to a depth of sixty fathoms and more. Groom and I found that the nauplii of Balanus perforatus show a very peculiar heliotropism. They are positively heliotropic when the light is very weak, but when they are exposed to a very strong light they very soon become negatively heliotropic. This explains the periodical migration. In the evening and very often during the night, the light which is reflected from the sky is very weak, and in this light the nauplii are positively heliotropic. As only the vertical components of the rays of the light can take effect, the horizontal ones annihilating each other, the animal is forced to move vertically upward to the surface. At daybreak, as soon as the light becomes sufficiently intense, the animal, by the influence of the light itself, becomes negatively heliotropic, and must go vertically downward. But why does it not go to the bottom of the sea? You know that water absorbs light, and the deeper we go downward into the ocean, the less the intensity of the light becomes.

Investigations of Forel and others have shown that at a depth of about 400 meters below the surface the intensity of the light is already so small that on a bright day it hardly affects longer the most sensitive photographic plate. Thus the nauplii, which, under the influence of intense light, have become negatively heliotropic, on their migration downward very soon must reach a depth where the light is so weak that they become positively heliotropic again, and necessarily must begin to move upward. But as soon as they come back again into stronger light they become negatively heliotropic, and must go downward again, and so on. So it happens that these animals, by the influence of the light, have to migrate periodically—during the night toward the surface, during the daytime downward, but no deeper than 400 meters below the surface.

Later on, at Wood's Holl, I tried to find out whether it was not possible to make other pelagic animals at the desire positively and negatively heliotropic. I found that this could be done easily in copepods and larvæ of Polygordius in different ways; for instance, by the influence of the light itself. Direct sunlight made positively heliotropic larvæ Polygordius negatively heliotropic within one or two minutes, but only as long as the temperature was above 10 degrees Centigrade. In these experiments great care was taken to keep the temperature of the animals constant. But when the temperature of the water in which the animals are kept was brought down to 7 degrees or less, the most intense sunlight was not more able to make the animals negatively heliotropic. On the other side, at a temperature of about 30 degrees the animals remained permanently negatively heliotropic, even in the weakest light. I found similar phenomena in copepods. These facts, it seems to me, must have some bearing on the depth migration of sea animals. At the surface of the Mediterranean, for instance, the temperature rises to a considerable height in summer. The consequence is that animals of a similar heliotropism, like the larvæ of Polygordius or copepods, cannot come to the surface, even at night, for the high temperature at the surface makes them negatively heliotropic, even toward weak light, which in winter time would make them move toward the surface. But on the other side it is clear that these animals cannot go down to the bottom of the sea. The temperature of the water decreases with increasing depth, and as soon as these animals on their migration downward come to water which is sufficiently cool they become positively heliotropic again, and now have to go upward; but this brings them back to warmer water, where they become negatively heliotropic again, etc. The investigations made at the zoological station at Naples have shown, indeed, that certain pelagic animals which in winter come up to the surface during the night, in summer always remain at a certain depth below the surface. These few examples may suffice to show how the light can determine the periodical depth migrations of pelagic animals.

It is unnecessary to say that it is impossible to exhaust this subject in so short a time. But, in order to prevent misunderstandings, I must mention that I do not believe that the light is the only physical influence which determines depth migrations of sea animals. As I have shown in former papers, gravitation, for instance, co-operates with light to bring about these periodical depth movements of pelagic animals, as well as the constant distribution of sea animals. It has been found that jelly fish which have been carried by the Gulf Stream from our latitude to the region of the midnight sun continued to migrate to and from the surface in the same periodicity as they did in their former home. In this case, I believe that the periodical depth migration is due to periodical changes in the amount of water contained in the animal. These changes are due to metabolic processes, which, however, are influenced in their periods by the change of day and night. Thus those metabolic changes adapt themselves in their periodicity by the change of day and night, and this periodicity remains the same, even if the animal later on is carried to the region of the midnight sun.

* From the Bulletin of the United States Fish Commission.

BOTANICAL GARDENS.*

ORIGIN AND DEVELOPMENT.

The cultivation of plants within small areas for their healing qualities by the monks of the middle ages appears to have been the beginning of the modern botanical garden, although these mediæval gardens doubtless took their origin from others of greater antiquity. Botanical gardens were thus primarily formed for purely utilitarian purposes, although the æsthetic study of planting and of flowers must doubtless have appealed to their owners and visitors. Their function as aids in scientific teaching and research, the one which at present furnishes the dominating reason for their existence, did not develop much, if at all, before the sixteenth century, and prior to the middle of the seventeenth century a considerable number existed in Europe, in which this function was recognized to a greater or less degree, of which those at Bologna, Montpellier, Leyden, Paris and Upsala were, perhaps, the most noteworthy. The ornamental and decorative taste for planting had meanwhile been slowly gaining ground, as well as the desire to cultivate rare or unusual species, and during the eighteenth century attained a high degree of development. Many persons of wealth and influence fostered this taste and became, through the employment of men skilled in botany and horticulture, generous patrons of science. The world was searched for new and rare plants, which were brought home to Europe for cultivation, and many sumptuous volumes, describing and delineating them, were published mainly through the same patronage. The older gardens were essentially private institutions, but as the rights of the people became more and more recognized, many existing establishments and an increasing number of newly founded ones became, to a greater or less extent, open to the public, either through an admittance fee or without charge. The four main elements of the modern botanical garden have thus been brought into it successively:

1. The utilitarian or economic.
2. The æsthetic.
3. The scientific or biologic.
4. The philanthropic.

These four elements have been given different degrees of prominence, depending mainly upon local conditions, some gardens being essentially æsthetic, some mainly scientific, while in our public parks we find the philanthropic function as the underlying feature, usually accompanied by more or less of the æsthetic and scientific.

The Economic Element.—In the broadest extension of this department of a botanical garden there might be included, to advantage, facilities for the display and investigation of all plants directly or indirectly useful to man, and their products. This conception would include forestry, pharmacognosy, agriculture, pomology, pathology and organic chemistry, and, in case the management regards bacteria as plants, bacteriology.

The display of the plants may be effected by growing such of them as will exist without protection in the locality in a plot, more or less individualized, commonly known as the Economic Garden, while those too tender for cultivation in the open are grown in the greenhouses either in a separate house or section, or scattered through the several houses or sections, in the temperatures best adapted to their growth. The display of plant products, best accompanied by mounted specimens of the species yielding them, by photographs and by plates, is accomplished by the Economic Museum, where these are arranged in glass or glass fronted cases, suitably classified and labeled. It is believed that the most useful results are obtained by arranging this museum by the products themselves, and thus not in biologic sequence but by bringing together all drugs, all fibers, all woods, all resins; where the same product is used in more than one industry the exhibit may be duplicated, more or less modified, without disadvantage.

The investigation of economic plants and their products is accomplished through the Scientific Department, and few valuable results can be reached unless the scientific equipment is well developed. The two departments must work conjointly, both on account of the necessity of knowing just what species is under investigation, its structure, distribution and literature, and in order that the most approved and exact methods may be used in the research. Any idea that the scientific element can be dispensed with in connection with economic studies is palpably untenable.

Teaching and research in agriculture, pomology and

* Vice Presidential address before Section G, American Association for the Advancement of Science, Buffalo, N. Y., August 24, 1896. Published in the official organ of the Association.

plant pathology are so well organized in America, through our National Department of Agriculture and our numerous agricultural colleges and schools, that there is no great necessity for providing elaborate equipments for those branches in botanical gardens. But in case the endowment of a garden were sufficiently large to enable them to be successfully prosecuted, in addition to more necessary work, there can be no doubt that important additions to knowledge would be obtained. On the other hand, no such liberal allowances have been made with us for forestry or pharmacognosy, and research and instruction in these sciences must prove of the greatest benefit to the country.

The Æsthetic Element.—The buildings, roads, paths and planting of a botanical garden should be constructed and arranged with reference to tasteful and decorative landscape effect. The possibilities of treatment will depend largely upon the topographical character of the area selected and the natural vegetation of the tract. The buildings required are: A fireproof structure or structures for museum, herbarium, libraries, laboratories and offices; a glass house with compartments kept at several different temperatures for exhibition, propagation and experimentation, or several separate glass houses; and to these will usually be added dwelling houses for some of the officers, a stable and other minor buildings. The character, number and sizes of the buildings generally depend on financial considerations. In placing the structures intended for the visiting public, considerations of convenient access, satisfactory water supply and the distribution of crowds must be borne in mind, in connection with the landscape design. The planting should follow, as nearly as possible, a natural treatment, except immediately around the larger buildings and at the entrances, where considerable formality is desirable for architectural reasons. It is especially desirable that as much natural treatment as possible should be given to the areas devoted to systematic planting—herbaceous grounds, frutecetum, arboretum. The rectilinear arrangement of plant beds found in most of the older gardens has become abhorrent to landscape lovers, and the sequence of families desired can usually be quite as well obtained by means of curved margined groups.

The cultivation of decorative plants, and especially the fostering of a taste for them, and the bringing of unusual or new species to attention and effecting their general introduction, are important functions of a botanical garden. For the accurate determination of these plants, information concerning their habits and structure, and suggestions regarding the conditions of their growth, the æsthetic side must rely on the scientific.

The Scientific or Biologic Element.—The important relations of the scientific department to the economic and æsthetic have already been alluded to. The library, herbarium, museums and laboratories are the sources whence exact information regarding the name, structure, habits, life processes and products of plants are derived, and they are the more useful as they are the more complete and thoroughly equipped. It is practically impossible for any one library to have all the literature of botany and related sciences; any one herbarium to possess an authentic and complete representation of all species of plants, or any one museum to be thoroughly illustrative; absolute perfection along these lines cannot be obtained, but the more closely it is approximated, the better the results. The research work of the scientific department should be organized along all lines of botanical inquiry, including taxonomy, morphology, anatomy, physiology and paleontology, and the laboratories should afford ample opportunities and equipment for their successful prosecution.

The arrangement of the areas devoted to systematic planting, and the proper labeling of the species grown, are important duties of the scientific department. The sequence of classes, orders and families is usually made to follow some "botanical system." It is highly desirable that this should be a system which indicates the natural relations of the families, as understood at the time the garden is laid out, and be elastic enough to admit of subsequent modification, as more exact information relative to those relationships is obtained. The weight of present opinion is overwhelmingly in favor of an arrangement from the more simple to the more complex, and this will apply not only to the systematic plantations, but to the systematic museum and the herbarium.

The scientific possibilities of a botanical garden are the greater if an organic or co-operative relationship exists between it and a university, thus affording ready facilities for information on other sciences.

The Philanthropic Element.—A botanical garden operates as a valuable philanthropic agency, both directly and indirectly. Its direct influence lies through its affording an orderly arranged institution for the instruction, information and recreation of the people, and it is more efficient for these purposes than a park, as it is more completely developed and liberally maintained. Its indirect, but equally important, philanthropic operation is through the discovery and dissemination of facts concerning plants and their products, obtained through the studies of the scientific staff and by others using the scientific equipment.

NUMBER AND DISTRIBUTION OF BOTANICAL GARDENS.

There are somewhat over 200 institutions denominated botanical gardens, but only a few of them meet the requirements of the foregoing sketch. Some are essentially pleasure parks, with the plants more or less labeled; most of them pay some attention to taxonomy and morphology; many to economic botany; while a small number are admirably equipped in all branches of the science.

I have drawn freely on Prof. Penhallow's first annual report of the Montreal Botanical Garden, published in 1886, for the following approximate statement of the number in different countries: Algeria, 1; Australia, 5; Austria-Hungary, 13; Belgium, 5; Brazil, 2; Canada, 1; Canary Islands, 1; Cape of Good Hope, 3; Ceylon, 1; Chile, 1; China, 1; Cochin China, 1; Denmark, 2; Ecuador, 1; Egypt, 1; France, 22; Germany, 36; Great Britain and Ireland, 12; Greece, 1; Guatemala, 1; Guiana, 1; Holland, 4; India, 7; Italy, 23; Japan, 1; Java, 1; Malta, 1; Mauritius, 1; Natal, 1; New Zealand, 1; Norway, 1; Peru, 1; Philippine Islands, 1; Portugal, 3; Reunion, 1; Roumania, 2; Russia, 16; Servia, 1; Siberia; 1; Spain, 2; Straits Settlements, 1; Sweden, 6; Switzerland, 4; Tasmania, 1; United States, 10; West Indies, 6.

NOTES ON SOME FOREIGN GARDENS.

1. Buitenzorg, Java.—This is the largest botanical garden, occupying some 1,100 acres, at altitudes from sea level to about 6,000 feet. It was founded by the Dutch government in 1817, and has been well supported. Affording as it does highly favorable conditions for the growth of tropical and subtropical plants under natural conditions it has yielded most important results, especially in taxonomy and plant physiology, many of which have been published in the ten large volumes of its "Annales."

2. The Royal Botanic Gardens at Kew are situated on the south bank of the Thames, about six miles west of Hyde Park Corner. They are reached by several railway routes, the time from Charing Cross being about 40 minutes, by steamer and by omnibus lines. The present area of the gardens is about 260 acres, an addition having been made during the past year. These world-famed gardens originated in the exotic garden of Lord Capel, in 1759. In 1840 they were adopted as a national establishment and opened as a public park. The botanic garden proper occupies about 70 acres, and the remainder is given to arboretum and pleasure grounds. There are two main greenhouses: 1, the palm house, 362 feet long, the central dome rising 66 feet; 2, the temperate house, of which the central portion is 212 feet long, 137 feet broad, and about 60 feet high, flanked by wings which give a total length of about 580 feet, the whole covering between one and one and one-half acres of ground. There are also fourteen other houses, grouped in two ranges and more or less connected, given to special collections. There are three botanical museums: 1. Devoted to economic products; 2, to miscellaneous products; 3, to timbers. There is also a large museum hall given to the exhibition of floral paintings by the late Marienne North. There is a small laboratory equipped for research in physiological botany. The herbarium and library occupy the old palace of the King of Hanover, near the main entrance to the garden, and they are the largest and most complete in the world. The herbaceous ground is planted in long parallel beds and contains several thousand species. The arboretum is thoroughly illustrative of all trees that will grow in the open at Kew, and the shrubs are, for the most part, cultivated in areas by themselves. There are numerous special features, such as the rock garden, the bamboo garden and the American garden.

The research work of Kew is principally economic and taxonomic. Around it center the 24 botanical gardens and botanical stations of the British colonies, which are manned chiefly by men who have studied or worked at Kew. The principal publications at present emanating from Kew are:

1. The Kew Bulletin of Miscellaneous Information.
2. Hooker's Icones Plantarum.
3. The continuation of Hooker's Flora of India.
4. The continuation of the Flora of Tropical Africa.
5. Annual Reports.
6. Index Kewensis.

The monographs and separate writings of its staff of scientific men are too numerous to review at this point.

3. The Royal Botanical Garden of Berlin is situated in the southwestern part of the city, but a project for moving it out into the country is now being seriously considered. The palm house reaches a height of about 90 feet, being the highest one yet constructed, and too high for satisfactory operation. The botanical museum is very extensive and has series of economic, systematic and archæological collections. The herbarium is one of the largest in the world. The systematic beds are arranged on a strictly modern sequence, and portions of the garden are devoted to plant geography and plant biology. The arboretum is not extensive. Among special features may be mentioned the alpine garden and the collections of the cacti. The garden is an institute of the University, where the principal laboratories are situated. There is also an institute of plant physiology with a small separate garden. The official publications of the Berlin Garden are the "Notizblatt" and annual reports. A series of volumes of "Jahrbücher" was issued some years ago. The publications of the garden staff are voluminous and cover all lines of botanical inquiry.

4. The long-established "Jardin des Plantes," the gardens of the Museum of Natural History at Paris, are situated in the heart of the city, fronting on the Seine. The conservatories are grouped near the main museum building at one end of the grounds, are very large and contain a great variety of plants. The botanical library, laboratories, and the enormous herbarium are in a separate, older building. The systematic beds are arranged in rows; owing to the limited size of the area devoted to them, they are much crowded, but contain a splendid assortment of species. But little space is given to trees; there are, however, some famous specimens. Many valuable contributions to the literature of botany along all its lines have emanated from this grand institution for over 100 years, published for the most part in the "Annales" and "Archives" of the Museum of Natural History and in the Bulletin of the Botanical Society of France.

5. The Botanical Garden of the University of Vienna was established about 1754 and is located in the heart of the city. There are here very important and extensive museums, herbaria and libraries, and one large fine greenhouse. The systematic plantations occupy the larger portion of the tract, and special areas are devoted to the cultivation of medicinal and other economic plants, to an arboretum of native trees, and to groups illustrating plant geography. The garden and associated laboratories provide equipment for the prosecution of all lines of botanical research.

6. The Botanical Garden of Geneva was founded in 1817, and is situated in the heart of the city, near the University. There are two small greenhouses, a very large and important herbarium and library and a small museum. The laboratories of the University are extensive and well equipped, affording capital facilities for work along all lines of botanical investigation. The De Candolle herbarium and library, and the Boissier herbarium and library, which are near by, afford, in connection with the collections of the garden, unsurpassed facilities for taxonomic study.

7. The Royal Botanic Garden of Edinburgh covers about sixty acres, of which about one-half was added to the older portion some twelve years ago; there are possibilities of still further enlargement. The main greenhouses have a frontage of about two hundred feet, the palm house rising some seventy feet, and there are six small special houses. The botanical museum, lecture room and laboratories are in one building, the large herbarium and library in another. The systematic plantations of herbaceous species are extensive, the rock garden being an especially strong feature. The development of arboretum and frutecetum in the newer portion of the tract has made good progress. The institution is in intimate relationship with the University, nearly all the instruction in botany being given at the garden. The research work has been extensive, along taxonomic, morphologic and physiologic lines.

8. The Royal Botanic Garden of Dublin, situated at Glasnevin, just without the city, founded through the influence of the Honorable Dublin Society in 1790, was for many years supported by this society, with the aid of government grants, and was transferred to the Science and Art Department in 1877. It includes about forty acres of undulating land, bounded to the north by the small river Tolka. There are eight greenhouses, most of them rather old, but containing a valuable collection. There is a small botanical museum and herbarium. The systematic herbaceous plantations are irregularly shaped beds arranged in a somewhat radial manner. The arboretum and frutecetum occupy about one-half of the area.

9. The Brussels Botanical Garden lies in the heart of the city and embraces not more than ten acres of land, of which about one-half is given to arboretum. The greenhouses are large but old. There is a very extensive herbarium and library. The systematic beds are arranged as quadrants of a circle, separated by concentric and radial paths. Special areas are devoted to ornamental and economic plants. Owing to the restricted size of the area available, a very dense grouping of plants is necessitated. The research work accomplished here has been mainly taxonomic. The Botanical Society of Belgium has its headquarters at the garden.

10. The Imperial Botanical Garden at St. Petersburg is in close affiliation with the Academy of Sciences and the University. There is here a famous herbarium, a large botanical library and museum and commodious and well stocked greenhouses. The garden publishes Acta, and many researches prosecuted there are printed in the Bulletin and Memoirs of the Imperial Academy.

11. The Royal Botanic Garden of Trinidad, situated at Port of Spain, was established in 1818, and now occupies about sixty-three acres, with some outlying plantations. There is a vast collection of tropical plants in cultivation, an extensive botanical library and herbarium and a small laboratory. The garden publishes Annual Reports and Bulletin, dealing especially with topics of economic application.

12. The Botanical Department of Jamaica, West Indies, operates extensive gardens at Kingston, smaller ones at Castleton and the several large cinchona plantations. The scientific collections and library are valuable. The department publishes Annual Reports and Bulletin, especially devoted to economic botany.

13. McGill University, at Montreal, Quebec, carries on a small botanical garden in connection with its laboratories. The Montreal Botanic Garden, begun in 1885 on about seventy-five acres of ground in Mount Royal Park, was soon abandoned, owing to political complications.

14. Among other foreign gardens of which mention must be made and of which a description would be interesting if our time allowed, are those at Munich, Würzburg, Tübingen, Stockholm, Copenhagen, Upsala, Zurich, Calcutta and Oxford.

BOTANICAL GARDENS IN THE UNITED STATES.

The first botanical garden established in America was begun by John Bartram in Philadelphia, in 1728. In it he placed a considerable number of plants obtained in the course of his extensive travels. The plot still remains, including the family homestead, somewhat modified, and it is a pleasure to know that it will be preserved as public ground.

Andre Michaux, in the latter part of the last century, planted gardens at Charleston, S. C., and New Durham, N. J., but they were essentially nurseries from which he sent seeds and plants to Europe.

In the year 1801 Dr. David Hosack, then professor of botany and materia medica in Columbia College, purchased twenty acres of ground in New York City and called it the Elgin Botanic Garden. In this tract he accumulated, with great labor during the next ten years, a very large and valuable collection of plants. The institution was transferred to the State of New York through the act of the Legislature in 1810, and was then known as the Botanic Garden of the State of New York. It was subsequently granted to Columbia College. Funds for its maintenance were not provided, however, and it was ultimately abandoned. Two catalogues of its plants were issued by Dr. Hosack, one in 1806 and another in 1811. The condition of botanical gardens in America at that time is indicated by the following note in Dr. Hosack's catalogue of 1806:

"I learn with pleasure that a botanic garden is proposed to be established near Boston and connected with the University at Cambridge. The Legislature of Massachusetts, with a munificence which does them honor, have granted for this purpose a tract of land, the value of which is estimated at thirty thousand dollars; and several individuals have evinced their liberality and love of science by voluntary subscriptions to the amount of fifteen thousand dollars toward the establishment and support of that institution. Another is also begun at Charleston, S. C., and a third is contemplated in New Jersey in connection with the College of Princeton."

In the year 1824 there was published at Lexington, Ky., the "First Catalogues and Circulars of the Botanical Garden of Transylvania University at Lexington, Ky., for the year 1824," by W. H. Richardson, M.D., President of the Board of Managers, and C. S. Rafinesque, Ph.D., Secretary. This rare pamphlet, which is not recorded in Dr. Call's very complete life and writings of Rafinesque, is of twenty-four pages and is printed alternately in English and French. It is essentially an appeal for plants and material for the garden and a list of species that it could furnish to kindred institutions. This garden was evidently short lived, inas-

much as in Rafinesque's "Neogenyton" of the following year, 1825, he remarks: "I mean, therefore, to indicate and propose in this small essay many of the numerous new genera of plants detected or ascertained, some of which were indicated last year, 1824, in the catalogue of the botanical garden which I have tried in vain to establish in Lexington."

The principal gardens at present operated and in course of development in the United States are as follows:

1. The botanic garden of Harvard University, at Cambridge, Mass., founded in 1805. There are about seven acres of land under cultivation, a small greenhouse, and a famous herbarium and library from which have flowed during the past forty years voluminous and invaluable contributions to taxonomy and morphology, especially of North American plants. There is also a small morphologic laboratory. The main laboratories and museums connected with the institution are situated in other of the Harvard buildings, a short distance away. The system of garden, libraries, museum, laboratories and herbaria operated by Harvard College is one of the most complete in existence. It is hard to say, indeed, in what respect it is not ideal, except in the rather wide distance separating the several elements and the small amount of land available for planting.

2. The Arnold Arboretum of Harvard University, at Jamaica Plain, Mass., was founded through a bequest of $100,000, made about 1870, by Mr. James Arnold, of Providence, R. I., to three trustees, to be used for the improvement of agriculture or horticulture. The trustees wisely determined to devote it to forestry and dendrology, and effected co-operative agreements with Harvard College and the city of Boston, which have now given us the greatest tree museum in existence, freely open to the visiting public. The planted area is about 160 acres, and will be materially increased in size. A small museum, library and herbarium building has been erected near the main entrance. The great Silva of North America and the journal Garden and Forest are noteworthy publications from this noble institution.

3. The botanic gardens of the United States Department of Agriculture, at Washington, have an extensive range of greenhouses and a large tract of land under cultivation. The herbarium of the department, now deposited with the United States National Museum, is very large and is at present increasing more rapidly than any other in America. There is a somewhat effective working library, which greatly needs material enlargement, and several poorly located and equipped laboratories, in which a vast amount of important investigation is being accomplished, under very unfavorable conditions, which urgently demand improvement. Publications include: Bulletin of the Botanical Division, Bulletin of the Division of Forestry, Bulletin of the Division of Plant Pathology and Physiology, Contributions from the United States National Herbarium, Year Book of the United States Department of Agriculture, and circulars of the several divisions.

4. The Missouri Botanical Garden at St. Louis, Mo., was established in 1889, through the provisions of the will of Mr. Henry Shaw, who for over thirty years previously had been bringing together material for it on the land about his residence, which was known as Shaw's Garden. There were in all some 670 acres devised to the institution under the will of the generous and philanthropic founder, and from the income yielded by much of this land, not nearly all the area being required for garden purposes, the institution derives its large maintenance fund which will certainly be greatly increased as the land becomes more valuable, and will supply an income sufficient to operate the institution in the most effective manner. There are several greenhouses, a very large and valuable herbarium and library, while the laboratories of the Shaw School of Botany, at Washington University, are in close relationship to the garden. Much important research, principally taxonomic, has been prosecuted. Publications consist of seven volumes of Annual Reports and nine "Contributions from the Shaw School of Botany."

5. The Botanical Garden of the Michigan Agricultural College was begun in 1877. There are now about three acres under high cultivation, exclusive of the arboretum and decorative grounds, which together cover several acres. There are several small greenhouses, an herbarium of about 60,000 specimens, a good botanical library and extensive, well equipped laboratories.

6. The University of California, at Berkeley, has a botanical garden of several acres, established some years ago, in which a large number of plants are grown. It furnishes a valuable adjunct to the work of the botanical department, which has well appointed laboratories, a working library and a large herbarium.

7. The University of Pennsylvania has recently established a garden of about three acres, in the immediate vicinity of its building, in Philadelphia, and has many species under cultivation. The extensive and well appointed laboratories of its school of biology, good library facilities and a small herbarium afford capital opportunity for research, especially in physiology and morphology.

8. Smith College, at Northampton, Mass., has also recently established a botanical garden, on the campus.

9. The Buffalo Botanical Garden, in South Park, Buffalo, N. Y., was commenced in 1893, and has since made rapid and encouraging progress. A small range of greenhouses has been built and others are planned. A beginning has been made in accumulating a library and herbarium, and much permanent planting has been accomplished.

10. The New York Botanical Garden.—The establishment of the New York Botanical Garden was authorized by the Legislature in 1891, and the enabling act was amended in 1894. The enterprise was inaugurated and the legislation procured by a committee of the Torrey Botanical Club, appointed in 1889. The act of incorporation provided that when the corporation created should have raised or secured by subscription a sum not less than $250,000 the Commissioners of Public Parks were authorized to set apart and appropriate a portion of one of the public parks, not exceeding 250 acres, and the Board of Estimate and Apportionment was authorized to issue bonds, aggregating the sum of $500,000, for the construction and equipment, within the grounds, of the necessary buildings. The subscription of $250,000 required by the act of incorporation was completed in June, 1895, and the Commissioners of Public Parks, in the following month, formally appropriated 250 acres of the northern part of Bronx Park for the purposes of the garden. Since that time the preparation of plans for the development of the tract has been steadily progressing, including designs for the museum building and a large horticultural house. This planning is still in progress, in charge of a commission of architects, engineers, gardeners and botanists, who will complete their work within a short time, and be ready to submit a complete scheme to the board of managers during the present autumn. Meanwhile, much preliminary work has been accomplished in clearing the ground, in grading, in the planting of borders, in the establishment of an extensive nursery, and in the accumulation of herbarium, museum, and library material. Through a co-operative agreement entered into with Columbia University, the herbarium and botanical library of the university will be deposited with the garden, and most of the research and graduate work of the university in botany will be carried on in the museum building.

The endowment fund has been materially increased, and about 430 persons have become annual members of the garden, contributing ten dollars a year each to its support. The publication of a bulletin has been commenced by the issue, in April, of the first number of Volume I.

N. L. BRITTON.

New York Botanical Garden.

A NEW ACETYLENE LAMP.

We illustrate herewith a new acetylene lamp of simple construction and easy management. The figure to the right gives a general view of the apparatus, and that to the left a vertical section.

The apparatus consists of an external receptacle, A, provided at one side with two apertures closed by screw plugs, L and L'. Within this there is a cylinder suspended by its upper part and not reaching the bottom of the receptacle, A. Finally, in the center there is another cylinder, D, which is closed at the bottom and open at the top. The cover of the apparatus is provided at B with a fishtail burner and at G with an aperture to permit of the passage of a vertical rod.

A NEW ACETYLENE LAMP—EXTERNAL VIEW AND VERTICAL SECTION.

The carbide of calcium is deposited at E in the central cylinder. At F there is a nearly horizontal rod that supports a wick whose lower extremity is immersed at M in the water that has been introduced into the external cylinder. The rod, G, permits of displacing the rod, F, through simple pressure.

It is now easy to explain the mode of operation. Let us suppose the lamp filled. It will then suffice to raise the rod, G, when the water absorbed by the wick will ascend through capillarity and fall drop by drop upon the carbide. The acetylene gas immediately produced is lighted at the burner, B. In order to arrest the operation of the lamp, it suffices to lower the rod, G, when the rod, F, will immediately rise and the water will no longer fall.

In order to prepare the lamp, it is necessary in the first place to remove all the internal parts, screw up the plugs, L and L', and fill with water to a level that is slightly above the first aperture when all the parts are in place.

The central cylinder is afterward charged with carbide up to a certain height, in taking care that the wick shall not be in too close proximity. All the internal parts are then replaced and the cover is put on. The regulating rod is lowered, and the lamp is ready to operate.

Before setting it in operation, it is necessary to make sure that the plugs are well screwed in and that the rod, F, is in condition to move freely.

It will be remarked that in this lamp there is no accumulation of gas, the latter being burned as soon as it is produced.—La Nature.

In 1870 it was decided to introduce the metric system of weights and measures into Russia by degrees, for the departments of posts and telegraphs, customs, and railways, and also in government contracts, while the system was to be taught in all schools, so that the rising generation might be familiar with it when grown up. Very little has, however, been accomplished in this direction; but at the Industrial and Commercial Congress, in connection with the Nijni-Novgorod Exhibition, the definite introduction of the metric system into Russia is to be brought forward by the Minister of Finance.

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